



# THE KAVERY ENGINEERING COLLEGE

(An Autonomous Institution)

Mecheri, Salem - 636 453.



Approved by AICTE, New Delhi  
Affiliated to Anna University

## DEPARTMENT OF CIVIL ENGINEERING

(M.E. - ENVIRONMENTAL ENGINEERING)

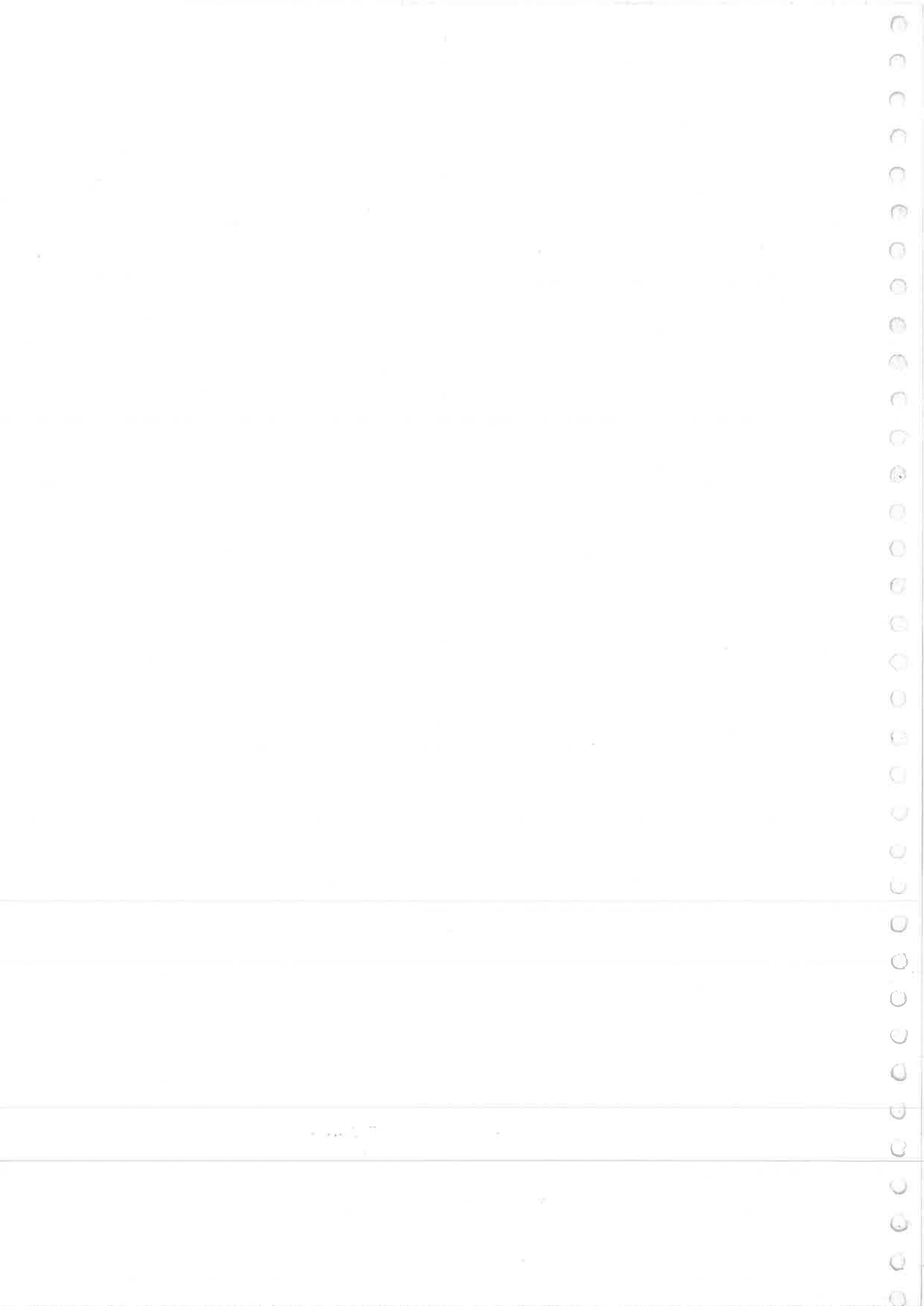


PG  
REGULATIONS  
**2024**

Academic Year 2024-25 onwards

AUTONOMOUS  
CURRICULUM AND

**SYLLABUS**  
**I-IV**  
SEMESTERS





# The Kavery Engineering College

Mecheri, Mettur Tk. Salem Dt – 636 453.

(An Autonomous Institution Approved by AICTE, New Delhi & Affiliated to Anna University)  
An ISO 9001:2015 certified Institution and accredited by NAAC with A+ grade.



## M.E. ENVIRONMENTAL ENGINEERING CHOICE BASED CREDIT SYSTEM CURRICULUM FOR SEMESTER I TO IV

(Applicable to the students admitted from the Academic year 2024-2025 onwards)

### VISION

- ❖ To attain global recognition as a commendable centre for quality Civil Engineering Education and Research

### MISSION

- ❖ To impart technical knowledge to the students for innovative design and construction solution providing.
- ❖ To develop the students in team work, leadership and to impart infrastructure project work skills.
- ❖ To imbibe ethical, sustainable and integrity value among students to give solutions to the global challenges.

### PROGRAMME EDUCATIONAL OBJECTIVES (PEOS)

- ❖ Gain knowledge and skills in Civil engineering which will enable them to have a career and professional accomplishment in the public or private sector organizations
- ❖ Become consultants on complex real life Civil Engineering problems related to Infrastructure development especially housing, construction, water supply, sewerage, transport, spatial planning.
- ❖ Become entrepreneurs and develop processes and technologies to meet desired infrastructure needs of society and formulate solutions that are technically sound, Economically feasible, and socially acceptable.
- ❖ Perform investigation for solving Civil Engineering problems by conducting research using modern equipment and software tools.
- ❖ Function in multi-disciplinary teams and advocate policies, systems, processes and equipment to support Civil Engineering.

### PROGRAMME OUTCOMES (POS)

After going through the four years of study, our graduates will exhibit ability to:

| PO | Graduate attribute      | Programme outcome                                                                                                                                                                                                    |
|----|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. | Research Aptitude       | An ability to independently carry out research/investigation and development work to solve practical problems                                                                                                        |
| 2. | Technical documentation | An ability to write and present a substantial technical report/document                                                                                                                                              |
| 3. | Technical competence    | Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program |

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**PROGRAM SPECIFIC OUTCOMES (PSOs)**

|    | <b>Graduate attribute</b>                        | <b>PROGRAMME SPECIFIC OUTCOMES (PSOs)</b>                                                                                                                        |
|----|--------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. | Handle complex problems                          | Use research based knowledge, methods, appropriate techniques, resources and tools to solve complex engineering issues with an understanding of the limitations. |
| 2. | Environmental Sustainability and societal Ethics | Ensure development of socially relevant and ecofriendly indigenous products by applying technical knowledge, ethical principles and sound engineering practices  |
| 3. | Life-long learning                               | Recognize the need for independent, life-long learning and engage in the broadest context of technological change.                                               |

**PEO/PO Mapping:**

| <b>PEO</b> | <b>PO &amp; PSO</b> |            |            |             |             |             |
|------------|---------------------|------------|------------|-------------|-------------|-------------|
|            | <b>PO1</b>          | <b>PO2</b> | <b>PO3</b> | <b>PSO1</b> | <b>PSO2</b> | <b>PSO3</b> |
| <b>I</b>   | 1                   | 1          | 3          | 3           | 1           | 2           |
| <b>II</b>  | 1                   | 1          | 3          | 3           | 3           | 1           |
| <b>III</b> | 2                   | 2          | 3          | 3           | 2           | 1           |
| <b>IV</b>  | 3                   | 2          | 3          | 2           | 2           | 1           |
| <b>V</b>   | 1                   | 1          | 2          | 2           | 2           | 1           |

(3-High, 2- Medium, 1- Low)

  
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**THE KAVERY ENGINEERING COLLEGE, MECHERI**  
**REGULATIONS - 2024**  
**CHOICE BASED CREDIT SYSTEM**  
**M. E. ENVIRONMENTAL ENGINEERING**  
**CURRICULUM & SYLLABI FOR I TO IV SEMESTERS**

| SEMESTER – I                          |                                                                  |              |   |   |        |               |     |       |          |  |
|---------------------------------------|------------------------------------------------------------------|--------------|---|---|--------|---------------|-----|-------|----------|--|
| Course Code                           | Course Title                                                     | Hours / Week |   |   | Credit | Maximum Marks |     |       | Category |  |
|                                       |                                                                  | L            | T | P |        | CA            | ESE | Total |          |  |
| Theory/Theory with Practical          |                                                                  |              |   |   |        |               |     |       |          |  |
| PSMT2401                              | Statistical Methods for Engineers                                | 4            | 0 | 0 | 4      | 40            | 60  | 100   | FC       |  |
| PEVT2401                              | Environmental Chemistry                                          | 3            | 0 | 0 | 3      | 40            | 60  | 100   | PCC      |  |
| PEVT2402                              | Environmental Microbiology                                       | 3            | 0 | 0 | 3      | 40            | 60  | 100   | PCC      |  |
| PEVT2403                              | Physical and Chemical Treatment Systems for Water and Wastewater | 3            | 0 | 0 | 3      | 40            | 60  | 100   | PCC      |  |
| PEVT2404                              | Water Transmission, Water Distribution and Sewerage Systems      | 3            | 0 | 0 | 3      | 40            | 60  | 100   | PCC      |  |
| PRMT 2411                             | Research Methodology and IPR                                     | 2            | 0 | 0 | 2      | 40            | 60  | 100   | RMC      |  |
| PAXC24XX                              | Audit Course I*                                                  | 2            | 0 | 0 | 0      | -             | -   | -     | AC       |  |
| Practical / Employability Enhancement |                                                                  |              |   |   |        |               |     |       |          |  |
| PEVL2401                              | Environmental Chemistry Laboratory                               | 0            | 0 | 4 | 2      | 60            | 40  | 100   | PCC      |  |
| PEVL2402                              | Environmental Microbiology Laboratory                            | 0            | 0 | 4 | 2      | 60            | 40  | 100   | PCC      |  |
| Total Credits to be earned            |                                                                  |              |   |   | 22     |               |     |       |          |  |

\* Audit Course is optional

| SEMESTER – II                         |                                                        |              |   |   |        |               |     |       |          |  |
|---------------------------------------|--------------------------------------------------------|--------------|---|---|--------|---------------|-----|-------|----------|--|
| Course Code                           | Course Title                                           | Hours / Week |   |   | Credit | Maximum Marks |     |       | Category |  |
|                                       |                                                        | L            | T | P |        | CA            | ESE | Total |          |  |
| Theory/Theory with Practical          |                                                        |              |   |   |        |               |     |       |          |  |
| PEVT2421                              | Biological Treatment Process for Wastewater            | 3            | 0 | 0 | 3      | 40            | 60  | 100   | PCC      |  |
| PEVT2422                              | Air and Noise Pollution Control Engineering            | 3            | 0 | 0 | 3      | 40            | 60  | 100   | PCC      |  |
| PEVT2423                              | Industrial Wastewater Pollution-Prevention and Control | 3            | 0 | 0 | 3      | 40            | 60  | 100   | PCC      |  |
| PEVE24XX                              | Professional Elective I                                | 3            | 0 | 0 | 3      | 40            | 60  | 100   | PEC      |  |
| PEVE24XX                              | Professional Elective II                               | 3            | 0 | 0 | 3      | 40            | 60  | 100   | PEC      |  |
| PEVE24XX                              | Professional Elective III                              | 3            | 0 | 0 | 3      | 40            | 60  | 100   | PEC      |  |
| PAXC24XX                              | Audit Course II*                                       | 2            | 0 | 0 | 0      | -             | -   | -     | AC       |  |
| Practical / Employability Enhancement |                                                        |              |   |   |        |               |     |       |          |  |
| PEVL2421                              | Environmental and Processes Monitoring Laboratory      | 0            | 0 | 6 | 3      | 60            | 40  | 100   | PCC      |  |
| Total Credits to be earned            |                                                        |              |   |   | 21     |               |     |       |          |  |

\* Audit Course is optional

  
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| SEMESTER – III                        |                               |              |   |    |        |               |     |       |          |
|---------------------------------------|-------------------------------|--------------|---|----|--------|---------------|-----|-------|----------|
| Course Code                           | Course Title                  | Hours / Week |   |    | Credit | Maximum Marks |     |       | Category |
|                                       |                               | L            | T | P  |        | CA            | ESE | Total |          |
| Theory/Theory with Practical          |                               |              |   |    |        |               |     |       |          |
|                                       | Professional Elective IV      | 3            | 0 | 0  | 3      | 40            | 60  | 100   | PEC      |
|                                       | Professional Elective V       | 3            | 0 | 0  | 3      | 40            | 60  | 100   | PEC      |
|                                       | Open Elective                 | 3            | 0 | 0  | 3      | 40            | 60  | 100   | OEC      |
| Practical / Employability Enhancement |                               |              |   |    |        |               |     |       |          |
| PEVL2431                              | Technical Seminar             | 0            | 0 | 2  | 1      | 60            | 40  | 100   | EEC      |
| PEVL2432                              | Industrial Training (2 Weeks) | 0            | 0 | 0  | 1      | 100           | -   | 100   | EEC      |
| PEVL2433                              | Project Work I                | 0            | 0 | 12 | 6      | 40            | 60  | 100   | EEC      |
| Total Credits to be earned            |                               |              |   |    | 17     |               |     |       |          |

| SEMESTER – IV                         |                 |              |   |    |        |               |     |       |          |  |
|---------------------------------------|-----------------|--------------|---|----|--------|---------------|-----|-------|----------|--|
| Course Code                           | Course Title    | Hours / Week |   |    | Credit | Maximum Marks |     |       | Category |  |
|                                       |                 | L            | T | P  |        | CA            | ESE | Total |          |  |
| Practical / Employability Enhancement |                 |              |   |    |        |               |     |       |          |  |
| PEVL2441                              | Project Work II | 0            | 0 | 24 | 12     | 40            | 60  | 100   | EEC      |  |
| Total Credits to be earned            |                 |              |   |    | 12     |               |     |       |          |  |

### AUDIT COURSES (AC)

Registration for any of these courses is optional to students

| Course Code                           | Course Title                       | Hours / Week |   |   | Credit | Maximum Marks |     |       | Category |
|---------------------------------------|------------------------------------|--------------|---|---|--------|---------------|-----|-------|----------|
|                                       |                                    | L            | T | P |        | CA            | ESE | Total |          |
| Practical / Employability Enhancement |                                    |              |   |   |        |               |     |       |          |
| PAXC2401                              | English for Research Paper Writing | 2            | 0 | 0 | 0      | -             | -   | -     | AC       |
| PAXC2402                              | Disaster Management                | 2            | 0 | 0 | 0      | -             | -   | -     | AC       |
| PAXC2403                              | Constitution of India              | 2            | 0 | 0 | 0      | -             | -   | -     | AC       |
| PAXC2404                              | நற்றமிழ் இலக்கியம்                 | 2            | 0 | 0 | 0      | -             | -   | -     | AC       |

### LIST OF PROFESSIONAL ELECTIVE COURSES [PEC]

| SEMESTER – II, ELECTIVE-I    |                                          |              |   |   |        |               |     |       |          |
|------------------------------|------------------------------------------|--------------|---|---|--------|---------------|-----|-------|----------|
| Course Code                  | Course Title                             | Hours / Week |   |   | Credit | Maximum Marks |     |       | Category |
|                              |                                          | L            | T | P |        | CA            | ESE | Total |          |
| Theory/Theory with Practical |                                          |              |   |   |        |               |     |       |          |
| PEVE2401                     | Solid and Hazardous Waste Management     | 3            | 0 | 0 | 3      | 60            | 40  | 100   | PEC      |
| PEVE2402                     | Natural Systems for Wastewater Treatment | 3            | 0 | 0 | 3      | 60            | 40  | 100   | PEC      |
| PEVE2403                     | Environmental System Analysis            | 3            | 0 | 0 | 3      | 60            | 40  | 100   | PEC      |

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| SEMESTER – II, ELECTIVE-II   |                                                      |              |   |   |        |               |     |       |          |
|------------------------------|------------------------------------------------------|--------------|---|---|--------|---------------|-----|-------|----------|
| Course Code                  | Course Title                                         | Hours / Week |   |   | Credit | Maximum Marks |     |       | Category |
|                              |                                                      | L            | T | P |        | CA            | ESE | Total |          |
| Theory/Theory with Practical |                                                      |              |   |   |        |               |     |       |          |
| PEVE2404                     | Environmental Impact Assessment                      | 3            | 0 | 0 | 3      | 60            | 40  | 100   | PEC      |
| PEVE2405                     | Septage and Onsite Wastewater Treatment Technologies | 3            | 0 | 0 | 3      | 60            | 40  | 100   | PEC      |
| PEVE2406                     | Sustainability Engineering                           | 3            | 0 | 0 | 3      | 60            | 40  | 100   | PEC      |
| PEVE2407                     | Project Formulation and Implementation               | 3            | 0 | 0 | 3      | 60            | 40  | 100   | PEC      |

| SEMESTER – II, ELECTIVE-III  |                                                   |              |   |   |        |               |     |       |          |
|------------------------------|---------------------------------------------------|--------------|---|---|--------|---------------|-----|-------|----------|
| Course Code                  | Course Title                                      | Hours / Week |   |   | Credit | Maximum Marks |     |       | Category |
|                              |                                                   | L            | T | P |        | CA            | ESE | Total |          |
| Theory/Theory with Practical |                                                   |              |   |   |        |               |     |       |          |
| PEVE2408                     | Advanced Oxidation Process                        | 3            | 0 | 0 | 3      | 60            | 40  | 100   | PEC      |
| PEVE2409                     | Computing Techniques in Environmental Engineering | 3            | 0 | 0 | 3      | 60            | 40  | 100   | PEC      |
| PEVE2410                     | Geo Environmental Engineering                     | 3            | 0 | 0 | 3      | 60            | 40  | 100   | PEC      |
| PEVE2411                     | Environmental Monitoring Instruments              | 3            | 0 | 0 | 3      | 60            | 40  | 100   | PEC      |

| SEMESTER – III, ELECTIVE-IV  |                                                                     |              |   |   |        |               |     |       |          |
|------------------------------|---------------------------------------------------------------------|--------------|---|---|--------|---------------|-----|-------|----------|
| Course Code                  | Course Title                                                        | Hours / Week |   |   | Credit | Maximum Marks |     |       | Category |
|                              |                                                                     | L            | T | P |        | CA            | ESE | Total |          |
| Theory/Theory with Practical |                                                                     |              |   |   |        |               |     |       |          |
| PEVE2412                     | Water Quality Modeling                                              | 3            | 0 | 0 | 3      | 60            | 40  | 100   | PEC      |
| PEVE2413                     | Marine Pollution and Control                                        | 3            | 0 | 0 | 3      | 60            | 40  | 100   | PEC      |
| PEVE2414                     | Climate Change and Modeling                                         | 3            | 0 | 0 | 3      | 60            | 40  | 100   | PEC      |
| PEVE2415                     | Operation and Maintenance of Water and Wastewater Treatment Systems | 3            | 0 | 0 | 3      | 60            | 40  | 100   | PEC      |

| SEMESTER – III, ELECTIVE- V  |                                                        |              |   |   |        |               |     |       |          |
|------------------------------|--------------------------------------------------------|--------------|---|---|--------|---------------|-----|-------|----------|
| Course Code                  | Course Title                                           | Hours / Week |   |   | Credit | Maximum Marks |     |       | Category |
|                              |                                                        | L            | T | P |        | CA            | ESE | Total |          |
| Theory/Theory with Practical |                                                        |              |   |   |        |               |     |       |          |
| PEVE2416                     | Air Quality Modeling                                   | 3            | 0 | 0 | 3      | 60            | 40  | 100   | PEC      |
| PEVE2417                     | Fate and Remediation of Emerging Contaminants          | 3            | 0 | 0 | 3      | 60            | 40  | 100   | PEC      |
| PEVE2418                     | Environmental Reaction Engineering                     | 3            | 0 | 0 | 3      | 60            | 40  | 100   | PEC      |
| PEVE2419                     | Membrane Separation for Water and Wastewater Treatment | 3            | 0 | 0 | 3      | 60            | 40  | 100   | PEC      |

  
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### List of Open Electives

| Course Code | Course Title                                           | Hours /Week |   |   | Credit | Maximum Marks |     |       | Category |
|-------------|--------------------------------------------------------|-------------|---|---|--------|---------------|-----|-------|----------|
|             |                                                        | L           | T | P |        | CA            | ESE | Total |          |
| PEVO2414    | Renewable Energy Technology                            | 3           | 0 | 0 | 3      | 40            | 60  | 100   | OEC      |
| POE2401     | IPR, Biosafety and Entrepreneurship                    | 3           | 0 | 0 | 3      | 40            | 60  | 100   | OEC      |
| POE2403     | Environmental Sustainability                           | 3           | 0 | 0 | 3      | 40            | 60  | 100   | OEC      |
| POE2405     | Machine Learning and Deep Learning                     | 3           | 0 | 0 | 3      | 40            | 60  | 100   | OEC      |
| POE2406     | IoT for Smart Systems                                  | 3           | 0 | 0 | 3      | 40            | 60  | 100   | OEC      |
| POE2408     | Cloud Computing Technologies                           | 3           | 0 | 0 | 3      | 40            | 60  | 100   | OEC      |
| POE2409     | Principles of Multimedia                               | 3           | 0 | 0 | 3      | 40            | 60  | 100   | OEC      |
| POE2413     | Sustainable Management                                 | 3           | 0 | 0 | 3      | 40            | 60  | 100   | OEC      |
| POE2414     | Micro and Small Business Management                    | 3           | 0 | 0 | 3      | 40            | 60  | 100   | OEC      |
| POE2415     | Intellectual Property Rights                           | 3           | 0 | 0 | 3      | 40            | 60  | 100   | OEC      |
| POE2416     | Ethical Management                                     | 3           | 0 | 0 | 3      | 40            | 60  | 100   | OEC      |
| POE2420     | Blockchain Technologies                                | 3           | 0 | 0 | 3      | 40            | 60  | 100   | OEC      |
| POE2423     | Energy Conservation and Management in Domestic Sectors | 3           | 0 | 0 | 3      | 40            | 60  | 100   | OEC      |
| POE2424     | Additive Manufacturing                                 | 3           | 0 | 0 | 3      | 40            | 60  | 100   | OEC      |
| POE2425     | Electric Vehicle Technology                            | 3           | 0 | 0 | 3      | 40            | 60  | 100   | OEC      |



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### SUMMARY

| S.No. | Name of the Programme: M.E. ENVIRONMENTAL ENGINEERING |                         |           |           |           |                  |
|-------|-------------------------------------------------------|-------------------------|-----------|-----------|-----------|------------------|
|       | SUBJECT AREA                                          | CREDITS<br>PER SEMESTER |           |           |           | CREDITS<br>TOTAL |
|       |                                                       | I                       | II        | III       | IV        |                  |
| 1     | FC                                                    | 04                      | 00        | 00        | 00        | 04               |
| 2     | PCC                                                   | 16                      | 12        | 00        | 00        | 28               |
| 3     | PEC                                                   | 00                      | 09        | 06        | 00        | 15               |
| 4     | RMC                                                   | 02                      | 00        | 00        | 00        | 02               |
| 5     | OEC                                                   | 00                      | 00        | 03        | 00        | 03               |
| 6     | EEC                                                   | 00                      | 00        | 08        | 12        | 20               |
| 7     | Non Credit/Audit Course                               |                         |           | 00        | 00        | 00               |
|       | <b>TOTAL CREDIT</b>                                   | <b>22</b>               | <b>21</b> | <b>17</b> | <b>12</b> | <b>72</b>        |

- FC – Foundation Courses  
PCC – Professional Core Courses  
PEC – Professional Elective Courses  
RMC – Research Methodology and IPR  
OEC – Open Elective Courses  
EEC – Employment Enhancement Course

  
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| PSMT2401                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                 | STATISTICAL METHODS FOR ENGINEERS |   |   |   |           |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|---|---|---|-----------|
|                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                 | Category                          | L | T | P | Credit    |
|                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                 | FC                                | 4 | 0 | 0 | 4         |
| <b>Course objectives</b>                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                 |                                   |   |   |   |           |
| This course is designed to provide the solid foundation on topics in various statistical methods which form the basis for many other areas in the mathematical sciences including statistics, modern optimization methods and risk modeling. It is framed to address the issues and the principles of estimation theory, testing of hypothesis, correlation and regression, design of experiments and multivariate analysis. |                                                                                                                                                                 |                                   |   |   |   |           |
| <b>UNIT – I</b>                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                 | <b>ESTIMATION THEORY</b>          |   |   |   | <b>12</b> |
| Estimators: Unbiasedness, Consistency, Efficiency and sufficiency – Maximum likelihood estimation- Method of moments                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                 |                                   |   |   |   |           |
| <b>UNIT – II</b>                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                 | <b>TESTING OF HYPOTHESIS</b>      |   |   |   | <b>12</b> |
| Sampling distributions – Small and large samples -Tests based on Normal, t, Chi square, and F distributions for testing of means, variance and proportions – Analysis of r x c tables – Goodness of fit.                                                                                                                                                                                                                     |                                                                                                                                                                 |                                   |   |   |   |           |
| <b>UNIT – III</b>                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                 | <b>CORRELATION AND REGRESSION</b> |   |   |   | <b>12</b> |
| Multiple and partial correlation – Method of least squares – Plane of regression – Properties of residuals – Coefficient of multiple correlation – Coefficient of partial correlation – Multiple correlation with total and partial correlations – Regression and partial correlations in terms of lower order co - efficient.                                                                                               |                                                                                                                                                                 |                                   |   |   |   |           |
| <b>UNIT – IV</b>                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                 | <b>DESIGN OF EXPERIMENTS</b>      |   |   |   | <b>12</b> |
| Analysis of variance – One way and two way classifications – Completely randomized design – Randomized block design – Latin square design - 2 <sup>2</sup> Factorial design.                                                                                                                                                                                                                                                 |                                                                                                                                                                 |                                   |   |   |   |           |
| <b>UNIT – V</b>                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                 | <b>MULTIVARIATE ANALYSIS</b>      |   |   |   | <b>12</b> |
| Random vectors and matrices – Mean vectors and covariance matrices – Multivariate normal density and its properties – Principal components: Population principal components – Principal components from standardized variables.                                                                                                                                                                                              |                                                                                                                                                                 |                                   |   |   |   |           |
| <b>Total: 60 periods</b>                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                 |                                   |   |   |   |           |
| <b>REFERENCES:</b>                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                 |                                   |   |   |   |           |
| 1.                                                                                                                                                                                                                                                                                                                                                                                                                           | Gupta, S.C., and Kapoor, V.K., "Fundamentals of Mathematical Statistics", 12 <sup>th</sup> Edition, Sultan Chand and Sons, 2020.                                |                                   |   |   |   |           |
| 2.                                                                                                                                                                                                                                                                                                                                                                                                                           | Jay L. Devore, "Probability and statistics for Engineering and the Sciences", 8 <sup>th</sup> Edition, Cengage Learning, 2014.                                  |                                   |   |   |   |           |
| 3.                                                                                                                                                                                                                                                                                                                                                                                                                           | Johnson, R.A., Miller, I and Freund J., "Miller and Freund's Probability and Statistics for Engineers", 9 <sup>th</sup> Edition, Pearson Education, Asia, 2016. |                                   |   |   |   |           |
| 4.                                                                                                                                                                                                                                                                                                                                                                                                                           | Johnson, R.A. and Wichern, D. W. "Applied Multivariate Statistical Analysis", 6 <sup>th</sup> Edition, Pearson Education, Asia, 2012.                           |                                   |   |   |   |           |
| 5.                                                                                                                                                                                                                                                                                                                                                                                                                           | Rice, J.A. "Mathematical Statistics and Data Analysis", 3rd Edition, Cengage Learning, 2015.                                                                    |                                   |   |   |   |           |

  
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| COURSE OUTCOMES:                                                                      |                                                                                                                                                                 | BT Mapped<br>(Highest<br>Level) |     |      |      |      |
|---------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|-----|------|------|------|
| After completing this course, students should demonstrate competency in the following |                                                                                                                                                                 |                                 |     |      |      |      |
| CO1:                                                                                  | Consistency, efficiency and unbiasedness of estimators, method of maximum likelihood estimation and Central Limit Theorem.                                      | K3                              |     |      |      |      |
| CO2:                                                                                  | Use statistical tests in testing hypotheses on data.                                                                                                            | K4                              |     |      |      |      |
| CO3:                                                                                  | Concept of linear regression, correlation, and its applications.                                                                                                | K2                              |     |      |      |      |
| CO4:                                                                                  | List the guidelines for designing experiments and recognize the key historical figures in Design of Experiments.                                                | K2                              |     |      |      |      |
| CO5:                                                                                  | Perform exploratory analysis of multivariate data, such as multivariate normal density, calculating descriptive statistics, testing for multivariate normality. | K2                              |     |      |      |      |
| Mapping of COs with POs and PSOs                                                      |                                                                                                                                                                 |                                 |     |      |      |      |
| COs/POs                                                                               | PO1                                                                                                                                                             | PO2                             | PO3 | PSO1 | PSO2 | PSO3 |
| CO1                                                                                   | 2                                                                                                                                                               | 1                               | 3   | -    | -    | -    |
| CO2                                                                                   | 2                                                                                                                                                               | 1                               | 3   | -    | -    | -    |
| CO3                                                                                   | 2                                                                                                                                                               | 1                               | 3   | -    | -    | -    |
| CO4                                                                                   | -                                                                                                                                                               | -                               | 1   | -    | -    | -    |
| CO5                                                                                   | 2                                                                                                                                                               | 1                               | 3   | -    | -    | -    |
| Avg.                                                                                  | 2                                                                                                                                                               | 1                               | 3   | -    | -    | -    |
| 1 – Slight, 2 – Moderate, 3 – Substantial. BT – Bloom's Taxonomy                      |                                                                                                                                                                 |                                 |     |      |      |      |

  
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| PRMT 2411                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                          | RESEARCH METHODOLOGY AND IPR                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |   |   |   |        |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|--------|
|                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                          | Category                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                          | RMC                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 2 | 0 | 0 | 2      |
| Course objectives                                                                                                                                                                                                                                                                                                                                           |                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                          | <ul style="list-style-type: none"> <li>To give an overview of the research methodology and explain the technique of defining a search problem</li> <li>To explain carrying out a literature search, its review, developing theoretical and conceptual frameworks and writing a review.</li> <li>To explain the art of interpretation and the art of writing research reports.</li> <li>To explain various forms of the intellectual property, its relevance and business impact in the changing global business environment.</li> <li>To discuss leading International Instruments concerning Intellectual Property Rights.</li> </ul> |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                                                                                                                    | RESEARCH DESIGN                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   | 6      |
| Overview of research process and design, Use of Secondary and exploratory data to answer the research question. Qualitative research, Observation studies, Experiments and Surveys.                                                                                                                                                                         |                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                                                                                                                   | DATA COLLECTION AND SOURCES                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   | 6      |
| Measurements, Measurement Scales, Questionnaires and Instruments, Sampling and methods. Data - Preparing, Exploring, examining and displaying.                                                                                                                                                                                                              |                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                                                                                                                  | DATA ANALYSIS AND REPORTING                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   | 6      |
| Overview of Multivariate analysis, Hypotheses testing and Measures of Association. Presenting Insights and findings using written reports and oral presentation                                                                                                                                                                                             |                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                                   | INTELLECTUAL PROPERTY RIGHTS                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   | 6      |
| Intellectual Property – The concept of IPR, Evolution and development of concept of IPR, IPR development process, Trade secrets, utility Models, IPR & Bio diversity, Role of WIPO and WTO in IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance. |                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                                                                                                                                    | PATENTS                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   | 6      |
| Patents – objectives and benefits of patent, Concept, features of patent, Inventive step, Specification, Types of patent application, process Filing, Examination of patent, Grant of patent, Revocation, Equitable Assignments, Licenses, Licensing of related patents, patent agents, Registration of patent agents.                                      |                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| Total: 30 periods                                                                                                                                                                                                                                                                                                                                           |                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| REFERENCES:                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| 1.                                                                                                                                                                                                                                                                                                                                                          | Cooper Donald R. Schindler Pamela S and Sharma J K, "Business Research Methods", Tata McGraw Hill Education, 11e (2012). |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| 2.                                                                                                                                                                                                                                                                                                                                                          | Catherine J. Holland, "Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets", Entrepreneur Press, 2007. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |

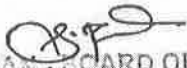
  
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|    |                                                                                                                                                                                      |
|----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3. | David Hunt, Long Nguyen, Matthew Rodgers, "Patent searching: tools & techniques", Wiley, 2007.                                                                                       |
| 4. | The Institute of Company Secretaries of India Statutory body under an Act of parliament.<br>"Professional Programme Intellectual Property Rights, Law and practice", September 2013. |

| COURSE OUTCOMES:                                                 |                                                                                                                                        | BT Mapped (Highest Level) |     |      |      |      |
|------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|---------------------------|-----|------|------|------|
| On completion of the course, the students will be able to        |                                                                                                                                        |                           |     |      |      |      |
| CO1:                                                             | Discuss research methodology and the technique of defining a research problem                                                          | K2                        |     |      |      |      |
| CO2:                                                             | Explain the functions of the literature review in research, carrying out a theoretical and conceptual frameworks and writing a review. | K2                        |     |      |      |      |
| CO3:                                                             | Explain various research designs and their characteristics.                                                                            | K2                        |     |      |      |      |
| CO4:                                                             | Explain the art of interpretation and the art of writing research reports.                                                             | K2                        |     |      |      |      |
| CO5:                                                             | Explain about the features and uses of patents.                                                                                        | K2                        |     |      |      |      |
| Mapping of COs with POs and PSOs                                 |                                                                                                                                        |                           |     |      |      |      |
| COs/POs                                                          | PO1                                                                                                                                    | PO2                       | PO3 | PSO1 | PSO2 | PSO3 |
| CO1                                                              | 2                                                                                                                                      | -                         | 2   | -    | -    | -    |
| CO2                                                              | 1                                                                                                                                      | -                         | 2   | -    | -    | -    |
| CO3                                                              | -                                                                                                                                      | -                         | -   | 2    | 1    | -    |
| CO4                                                              | -                                                                                                                                      | -                         | -   | 2    | -    | -    |
| CO5                                                              | -                                                                                                                                      | -                         | -   | -    | 2    | 2    |
| Avg.                                                             | 1                                                                                                                                      | -                         | -   | -    | 1    | -    |
| 1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom's Taxonomy |                                                                                                                                        |                           |     |      |      |      |

  
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|                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                       |          |   |   |   |                   |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|---|---|---|-------------------|
| PEVT2401                                                                                                                                                                                                                                                                                                                                                                                                                                               | ENVIRONMENTAL CHEMISTRY                                                                                                                                                                                                                               |          |   |   |   |                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                       | Category | L | T | P | Credit            |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                       | PCC      | 3 | 0 | 0 | 3                 |
| Course objectives                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                       |          |   |   |   |                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <ul style="list-style-type: none"><li>To educate the students in the area of water, air and soil chemistry</li><li>To explain the theoretical basis and observational methods for study of contaminants and interactions in the environment</li></ul> |          |   |   |   |                   |
| UNIT – I                                                                                                                                                                                                                                                                                                                                                                                                                                               | FUNDAMENTALS                                                                                                                                                                                                                                          |          |   |   |   | 9                 |
| Stoichiometry and mass balance-Chemical equilibria, acid base, solubility product (K <sub>sp</sub> ), heavy metal precipitation, amphoteric hydroxides, CO <sub>2</sub> solubility in water and species distribution – Ocean acidification, Chemical kinetics, First order- 12 Principles of green chemistry.                                                                                                                                          |                                                                                                                                                                                                                                                       |          |   |   |   |                   |
| UNIT – II                                                                                                                                                                                                                                                                                                                                                                                                                                              | AQUATIC CHEMISTRY                                                                                                                                                                                                                                     |          |   |   |   | 11                |
| Water and wastewater quality parameters- environmental significance and determination; Fate of chemicals in aquatic environment, volatilization, partitioning, hydrolysis, photochemical transformation– Degradation of synthetic chemicals - Metals, complex formation, oxidation and reduction, pE – pH diagrams, redox zones – sorption- Colloids; electrical properties, double layer theory, environmental significance of colloids, coagulation. |                                                                                                                                                                                                                                                       |          |   |   |   |                   |
| UNIT – III                                                                                                                                                                                                                                                                                                                                                                                                                                             | ATMOSPHERIC CHEMISTRY                                                                                                                                                                                                                                 |          |   |   |   | 7                 |
| Atmospheric structure – chemical and photochemical reactions – photochemical smog, Ozone layer depletion – greenhouse gases and global warming, CO <sub>2</sub> capture and sequestration – acid rain- origin and composition of particulates, black carbon, air quality parameters determination.                                                                                                                                                     |                                                                                                                                                                                                                                                       |          |   |   |   |                   |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                                                                                                                              | SOIL CHEMISTRY                                                                                                                                                                                                                                        |          |   |   |   | 9                 |
| Nature and composition of soil - Clays- cation exchange capacity-acid base and ion-exchange reactions in soil – agricultural chemicals in soil-reclamation of contaminated land; salt by leaching- Heavy metals by electrokinetic remediation.                                                                                                                                                                                                         |                                                                                                                                                                                                                                                       |          |   |   |   |                   |
| UNIT – V                                                                                                                                                                                                                                                                                                                                                                                                                                               | EMERGING POLLUTANTS                                                                                                                                                                                                                                   |          |   |   |   | 9                 |
| Heavy metals-chemical speciation –Speciation of Hg & As- endocrine disturbing chemicals Pesticides, Dioxins & Furan, PCBs, PAHs and Fluro compounds toxicity- Nano materials, CNT, titania, composites, environmental applications.                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                       |          |   |   |   |                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                       |          |   |   |   | Total: 45 periods |
| REFERENCES:                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                       |          |   |   |   |                   |
| 1.                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Sawyer, C.N., Mac Carty, P.L. and Parkin, G.F., "Chemistry for Environmental Engineering and Science", Tata McGraw – Hill, Fifth edition, New Delhi 2003.                                                                                             |          |   |   |   |                   |
| 2.                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Colin Baird., Environmental Chemistry, Freeman and company, New York, 5 <sup>th</sup> Edition, 2012.                                                                                                                                                  |          |   |   |   |                   |
| 3.                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Manahan, S.E., "Environmental Chemistry", Ninth Edition, CRC press, 2009                                                                                                                                                                              |          |   |   |   |                   |
| 4.                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Ronald A. Hites, "Elements of Environmental Chemistry", Wiley, 2nd Edition, 2012.                                                                                                                                                                     |          |   |   |   |                   |

  
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| COURSE OUTCOMES:<br>On completion of the course, the students will be able to |                                                                                            | BT Mapped<br>(Highest Level) |     |      |      |      |
|-------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|------------------------------|-----|------|------|------|
| CO1:                                                                          | Students will gain competency in solving environmental issues of chemicals-based pollution | K2                           |     |      |      |      |
| CO2:                                                                          | Ability to determine chemicals mobility in aquatic systems                                 | K2                           |     |      |      |      |
| CO3:                                                                          | Ability to identify contaminating chemicals in air and their fate                          | K2                           |     |      |      |      |
| CO4:                                                                          | Understand the type of soil contaminants and provide remediation.                          | K4                           |     |      |      |      |
| CO5:                                                                          | Identify emerging environmental contaminants including speciation                          | K2                           |     |      |      |      |
| Mapping of COs with POs and PSOs                                              |                                                                                            |                              |     |      |      |      |
| COs/POs                                                                       | PO1                                                                                        | PO2                          | PO3 | PSO1 | PSO2 | PSO3 |
| CO1                                                                           | 3                                                                                          | 1                            | 2   | -    | 2    | 1    |
| CO2                                                                           | 2                                                                                          | 1                            | 3   | 3    | 2    | 1    |
| CO3                                                                           | 2                                                                                          | 1                            | 2   | 2    | 2    | 1    |
| CO4                                                                           | 2                                                                                          | 1                            | 3   | 2    | 2    | -    |
| CO5                                                                           | 2                                                                                          | 2                            | 3   | 2    | 2    | 1    |
| Avg.                                                                          | 2                                                                                          | 1                            | 3   | 2    | 2    | 1    |
| 1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom's Taxonomy              |                                                                                            |                              |     |      |      |      |

  
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| ENVIRONMENTAL MICROBIOLOGY                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Category | L | T | P | Credit |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|---|---|---|--------|
| PEVT2402                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | PCC      | 3 | 0 | 0 | 3      |
| Course objectives                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <ul style="list-style-type: none"> <li>To provide a basic understanding on microbiology relevant to environmental engineering for candidates.</li> <li>To gain knowledge on morphology, behavior and biochemistry of bacteria, fungi, protozoa, viruses, and algae.</li> <li>To understand the microbiology of wastewater, sewage sludge and solid waste treatment processes. And to understand the aspects of nutrient removal and the transmission of disease-causing organisms.</li> <li>To have an exposure to toxicology due to industrial products and byproducts.</li> </ul> |          |   |   |   |        |
| UNIT - I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | FUNDAMENTALS OF MICROBIOLOGY                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |          |   |   |   | 10     |
| Classification of microorganisms – prokaryotic, eukaryotic, cell structure, characteristics, importance, introduction to water, soil and air borne pathogens and Parasites and their effects on human, animal and plant health, transmission of pathogens, transmissible diseases – bacterial, viral, protozoan, and helminths parasites, concentration and detection of virus. Control of micro-organisms preservation of microorganisms, DNA, RNA, replication, recombinant DNA technology, their potential applications and intellectual property rights |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |          |   |   |   |        |
| UNIT - II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | MICROBIAL DIVERSITY AND NUTRIENT TURNOVER                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |          |   |   |   | 10     |
| Distribution of microorganisms in different environments – diversity of microorganisms – fresh and marine, terrestrial – microbes in surface soil, air – outdoor and Indoor, aerosols, bio safety in laboratory – extreme environment – archae bacteria – occurrence in water supplies – problems and control, biogeochemical cycles – nitrogen, carbon, phosphorus, sulphur – Role of Microorganism in nutrient cycle                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |          |   |   |   |        |
| UNIT - III                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | METABOLISM OF MICROORGANISMS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |          |   |   |   | 9      |
| Nutrition and metabolism in microorganisms, growth phases, carbohydrate, protein, lipid metabolism – respiration, aerobic and anaerobic-fermentation, glycolysis, Kreb's cycle, hexose monophosphate pathway, electron transport system, oxidative phosphorylation, environmental factors, enzymes, bioenergetics, disruption in metabolism and disease, biodegradation of organic pollutants                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |          |   |   |   |        |
| UNIT - IV                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | MICROBIOLOGY OF WASTEWATER TREATMENT SYSTEMS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |          |   |   |   | 8      |
| Microbiology of biological treatment processes – aerobic and anaerobic, $\alpha$ -oxidation, $\beta$ -oxidation, nitrification and denitrification, eutrophication, nutrients removal – BOD, nitrogen, phosphate microbiology of sewage sludge - indicator organisms of water – coliforms - total coliforms, E-coli, streptococcus, clostridium, Bioleaching                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |          |   |   |   |        |
| UNIT - V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | TOXICOLOGY                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |          |   |   |   | 8      |
| Ecotoxicology – toxicants and toxicity, factors influencing toxicity, Effects – acute, chronic, test organisms – toxicity testing-lab and field-testing methods, bioconcentration – Bioaccumulation, biomagnification, bioassay, biomonitoring                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |          |   |   |   |        |
| Total: 45+30= 75 Periods                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |          |   |   |   |        |
| REFERENCES:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |          |   |   |   |        |

  
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|    |                                                                                                                                                              |
|----|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. | Bhatia S.C. "Hand Book of Environmental Microbiology", Part 1 and 2, Atlantic Publisher, 2008                                                                |
| 2. | Gabriel Bitton, Wastewater Microbiology, 2nd Edition, 3. Raina M. Maier, Ian L. Pepper, Charles P. Gerba, "Environmental Microbiology", Academic Press, 2000 |
| 3. | Volodymyr Ivanov, Environmental Microbiology for Engineers 2nd Edition, CRC Press, 2015, ISBN 9781498702126                                                  |
| 4. | Nduka Okafor, Environmental Microbiology of Aquatic and Waste systems, Springer Publishers, 2011, ISBN 978-94-007-1459-5                                     |
| 5. | Stanley E. Manahan, "Environmental Science and Technology", Lewis Publishers, 2008.                                                                          |
| 6. | Hurst, C.J. Manual of "Environmental Microbiology", 2nd Ed. ASM PRESS, Washington, D.C. ISBN 1- 55581 - 199 - X. 2002                                        |

| COURSE OUTCOMES:                                                     |                                                                                                                                                                                                                     | BT Mapped<br>(Highest Level) |     |      |      |      |
|----------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|-----|------|------|------|
| • On completion of the course, the student is expected to be able to |                                                                                                                                                                                                                     |                              |     |      |      |      |
| CO1:                                                                 | Explain the basic importance and functional elements of environmental microbiology including the potential applications in the environment and intellectual property rights.                                        | K2                           |     |      |      |      |
| CO2:                                                                 | Understand and describe the type of microorganisms in the environment, their importance in water supplies and the role of microorganisms in the cycling of nutrients in an ecosystem                                | K2                           |     |      |      |      |
| CO3:                                                                 | Understand the metabolic processes on carbohydrates, protein and lipids, importance of enzymes, production of energy and the various additional metabolic processes.                                                | K2                           |     |      |      |      |
| CO4:                                                                 | Select and apply appropriate methods for assessing the water, air and soil borne pathogens, their health implications, and importance of microbes in aerobic and anaerobic cycles and deterioration of water bodies | K2                           |     |      |      |      |
| CO5:                                                                 | Conduct testing and research on toxicology, understand the importance of test organisms, environmental applications such as biomagnifications, biomonitoring and in developing risk-based standards                 | K2                           |     |      |      |      |
| Mapping of COs with POs and PSOs                                     |                                                                                                                                                                                                                     |                              |     |      |      |      |
| COs/POs                                                              | PO1                                                                                                                                                                                                                 | PO2                          | PO3 | PSO1 | PSO2 | PSO3 |
| CO1                                                                  | 3                                                                                                                                                                                                                   | 1                            | 2   | 1    | 1    | 1    |
| CO2                                                                  | 3                                                                                                                                                                                                                   | 1                            | 3   | 3    | 2    | 1    |
| CO3                                                                  | 3                                                                                                                                                                                                                   | 1                            | 2   | 1    | 3    | 1    |
| CO4                                                                  | 2                                                                                                                                                                                                                   | 1                            | 2   | 2    | 2    | 2    |
| CO5                                                                  | 3                                                                                                                                                                                                                   | 2                            | 3   | 2    | 2    | 1    |
| Avg.                                                                 | 3                                                                                                                                                                                                                   | 1                            | 2   | 2    | 2    | 1    |
| 1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom's Taxonomy     |                                                                                                                                                                                                                     |                              |     |      |      |      |

  
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| PEVT2403                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | PHYSICAL AND CHEMICAL TREATMENT SYSTEMS FOR WATER AND WASTEWATER                                                                                                                                                                                                                                                                                                                                                                                                                                                    |          |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Category | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | PCC      | 3 | 0 | 0 | 3      |
| Course objectives                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |          |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <ul style="list-style-type: none"><li>• To understand about the various pollutants present in water and wastewater and to choose the respective physico-chemical systems for effective treatment</li><li>• To apply the knowledge for municipal, industrial water and wastewater treatment plants and design suitable treatment schemes</li><li>• To gain advance knowledge on the emerging environmental issues on treatment systems and conduct research to identify most appropriate treatment schemes</li></ul> |          |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | INTRODUCTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |          |   |   |   | 5      |
| Pollutants in water and wastewater-characteristics, standards for performance- significance of physico-chemical treatment-Selection criteria-types of reactor-reactor selection-batch-continuous type-kinetics                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |          |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | TREATMENT PRINCIPLES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |          |   |   |   | 10     |
| Physical treatment - screening – mixing, equalization –sedimentation – filtration – evaporation-incineration-gas transfer-mass transfer coefficient adsorption – isotherms – membrane separation. Reverse Osmosis, nanofiltration, ultrafiltration and electrodialysis, distillation- stripping and crystallization – recent advances. Principles of Chemical treatment- Coagulation - flocculation- Precipitation – flotation - solidification and stabilization-Disinfection, Ion exchange, Electrolytic methods, Solvent extraction-advanced oxidation/reduction-recent trends |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |          |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | DESIGN OF MUNICIPAL WATER TREATMENT PLANTS                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |          |   |   |   | 10     |
| Selection of treatment-design of municipal water treatment plant units-aerators-chemical feeding-flocculation-clarifier-tube settling-filters-rapid sand filters, slow sand filter, pressure filter, dual media filter – disinfection flow charts- layouts –hydraulic profile. PID-construction and O&M aspects- case studies. residue management – upgradation of existing plants – recent trends.                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |          |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | DESIGN OF INDUSTRIAL WATER TREATMENT PLANTS                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |          |   |   |   | 10     |
| Design of industrial water treatment units-selection of process-design of softeners –demineralisers- Reverse osmosis plants-flow charts-layouts-hydraulic profile, PID-construction and O&M aspects- case studies, residue management-upgradation of existing plants –recent trends.                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |          |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | DESIGN OF WASTEWATER TREATMENT PLANTS                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |          |   |   |   | 10     |
| Design of municipal wastewater treatment units-screens- grit chamber-settling tanks- sludge thickening - sludge dewatering systems - sludge drying beds - design of industrial wastewater treatment units - equalization - neutralization - chemical feeding devices – mixers - floatation units - oil skimmer – flowcharts – layouts – hydraulic profile, PID, construction and O&M aspects – case studies, retrofitting - residue management – upgradation of existing plants – recent trends                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |          |   |   |   |        |

  
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| Total: 45 Periods  |                                                                                                                                                                     |
|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>REFERENCES:</b> |                                                                                                                                                                     |
| 1.                 | Metcalf & Eddy, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater engineering, treatment and reuse, Fourth Edition, McGraw-Hill, 2017 |
| 2.                 | Lee, C.C. and Shun dar Lin, "Handbook of Environmental Engineering Calculations", McGraw Hill, New York, 1999.                                                      |
| 3.                 | Qasim.S.R., Guang Zhu., "Wastewater Treatment and Reuse" – Volume 1 & 2 2018.                                                                                       |
| 4.                 | CPHEEO manual – "Manual for sewerage and sewage treatment systems" – Part A,B,C. Ministry of Urban development, New Delhi, 2013.                                    |
| 5.                 | CPHEEO manual – "Manual for water supply and treatment" – Ministry of Urban development, New Delhi, 1999.                                                           |

| COURSE OUTCOMES:                                                   |                                                                                                                                                                                                                                  | BT Mapped<br>(Highest Level) |     |      |      |      |
|--------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|-----|------|------|------|
| On Completion of the course, the student is expected to be able to |                                                                                                                                                                                                                                  |                              |     |      |      |      |
| CO1:                                                               | Explain the significance of various pollutants present in water, wastewater and develop the kinetics for reactor design                                                                                                          | K2                           |     |      |      |      |
| CO2:                                                               | Choose the relevant physico-chemical systems for effective water and wastewater treatment                                                                                                                                        | K2                           |     |      |      |      |
| CO3:                                                               | Design the treatment scheme for municipal and industrial water, wastewater to meet the specific needs on residue management and up gradation of existing plants                                                                  | K2                           |     |      |      |      |
| CO4:                                                               | Identify environmental issues in the society on wastewater treatment and formulate technical solutions that are economically feasible and socially acceptable                                                                    | K2                           |     |      |      |      |
| CO5:                                                               | Conduct research to identify and design most appropriate treatment schemes for the emerging environmental issues on treatment systems in collaboration with municipalities, corporation, pollution control boards and industries | K2                           |     |      |      |      |
| Mapping of COs with POs and PSOs                                   |                                                                                                                                                                                                                                  |                              |     |      |      |      |
| COs/POs                                                            | PO1                                                                                                                                                                                                                              | PO2                          | PO3 | PSO1 | PSO2 | PSO3 |
| CO1                                                                | 2                                                                                                                                                                                                                                | 1                            | 3   | 2    | 3    | 1    |
| CO2                                                                | 1                                                                                                                                                                                                                                | 1                            | 3   | 2    | 3    | 1    |
| CO3                                                                | 1                                                                                                                                                                                                                                | 1                            | 3   | 2    | 3    | 1    |
| CO4                                                                | 2                                                                                                                                                                                                                                | 1                            | 3   | 2    | 3    | 1    |
| CO5                                                                | 2                                                                                                                                                                                                                                | 2                            | 3   | 3    | 3    | 1    |
| Avg.                                                               | 2                                                                                                                                                                                                                                | 1                            | 3   | 2    | 3    | 1    |
| 1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy  |                                                                                                                                                                                                                                  |                              |     |      |      |      |

  
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|                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                           |          |   |   |   |                   |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|----------|---|---|---|-------------------|
| PEVT2404                                                                                                                                                                                                                                                                                                                                                            | WATER TRANSMISSION, WATER DISTRIBUTION<br>AND SEWERAGE SYSTEMS                                                                            |          |   |   |   |                   |
|                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                           | Category | L | T | P | Credit            |
|                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                           | PCC      | 3 | 0 | 0 | 3                 |
| Course objectives                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                           |          |   |   |   |                   |
|                                                                                                                                                                                                                                                                                                                                                                     | • To educate the students on economic design of water mains, distribution system and sewer networks                                       |          |   |   |   |                   |
| UNIT – I                                                                                                                                                                                                                                                                                                                                                            | GENERAL HYDRAULICS                                                                                                                        |          |   |   |   | 8                 |
| Fluid properties; fluid flow – continuity principle, energy principle and momentum principle; frictional head loss in free and pressure flow, minor head losses, carrying capacity– flow measurement, need for transport of water and wastewater and types                                                                                                          |                                                                                                                                           |          |   |   |   |                   |
| UNIT – II                                                                                                                                                                                                                                                                                                                                                           | WATER TRANSMISSION MAINS                                                                                                                  |          |   |   |   | 9                 |
| Planning of water system – design of storage reservoirs - water transmission main design- compound gravity and pumping main; selection of pumps and characteristics curve - economics: specials, jointing, laying and maintenance, water hammer analysis;                                                                                                           |                                                                                                                                           |          |   |   |   |                   |
| UNIT – III                                                                                                                                                                                                                                                                                                                                                          | WATER DISTRIBUTION                                                                                                                        |          |   |   |   | 9                 |
| Service reservoirs-types and design, water distribution pipe networks design, analysis and optimization – appurtenances – corrosion prevention – minimization of water losses – leak detection, plumbing for water supply in high rise buildings, use of computer software in water transmission, water distribution design – EPANET 2.0, LOOP version 4.0, BRANCH, |                                                                                                                                           |          |   |   |   |                   |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                                           | WASTEWATER COLLECTION AND CONVEYANCE                                                                                                      |          |   |   |   | 10                |
| Planning factors – design of sanitary sewer; partial flow in sewers, economics of sewer design; wastewater pumps and pumping stations- sewer appurtenances; material, construction, inspection and maintenance of sewers; design of sewer outfalls-mixing conditions; conveyance of corrosive wastewaters, plumbing for drains in high rise buildings               |                                                                                                                                           |          |   |   |   |                   |
| UNIT – V                                                                                                                                                                                                                                                                                                                                                            | STORM WATER DRAINAGE                                                                                                                      |          |   |   |   | 9                 |
| Necessity- combined and separate system; estimation of storm water runoff - formulation of rainfall intensity duration and frequency relationships- rational methods, use of computer software in sewer design–sewer, SewerCAD, SewerGEMS                                                                                                                           |                                                                                                                                           |          |   |   |   |                   |
|                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                           |          |   |   |   | Total: 45 Periods |
| REFERENCES:                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                           |          |   |   |   |                   |
| 1.                                                                                                                                                                                                                                                                                                                                                                  | Pramod R. Bhawe, Rajesh Gupta, "Analysis of Water Distribution Networks", Alpha Science International, 2006                               |          |   |   |   |                   |
| 2.                                                                                                                                                                                                                                                                                                                                                                  | Bajwa, G.S, "Practical Handbook on Public Health Engineering", Deep Publishers, Shimla, 2003                                              |          |   |   |   |                   |
| 3.                                                                                                                                                                                                                                                                                                                                                                  | "Manual on water supply and Treatment", CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 1999,                      |          |   |   |   |                   |
| 4.                                                                                                                                                                                                                                                                                                                                                                  | "Manual on Sewerage and Sewage Treatment Part-A Engineering", CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 2013 |          |   |   |   |                   |

  
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| Mapping of COs with POs and PSOs |     |     |     |      |      |      |
|----------------------------------|-----|-----|-----|------|------|------|
| COs/POs                          | PO1 | PO2 | PO3 | PSO1 | PSO2 | PSO3 |
| CO1                              | 2   | -   | 3   | 2    | 2    | 1    |
| CO2                              | 1   | 1   | 3   | 3    | 1    | 1    |
| CO3                              | 1   | 1   | 3   | 3    | 2    | 1    |
| CO4                              | 1   | 1   | 3   | 3    | 1    | 1    |
| CO5                              | 1   | 1   | 3   | 3    | 2    | 1    |
| Avg.                             | 1   | 1   | 3   | 3    | 3    | 1    |

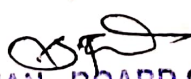
1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom's Taxonomy

  
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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |                                                                                                |   |   |   |        |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|------------------------------------------------------------------------------------------------|---|---|---|--------|
| PEVL2401                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |  | ENVIRONMENTAL CHEMISTRY LABORATORY                                                             |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |  | Category                                                                                       | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |  | PCC                                                                                            | 0 | 0 | 4 | 2      |
| Course objectives                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |  | To train the students in the analysis of physico-chemical parameters with hands on experience. |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |                                                                                                |   |   |   |        |
| LIST OF EXPERIMENTS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |  |                                                                                                |   |   |   |        |
| <div>1. Preparation of culture media,</div> <div>2. Isolation and culturing of microorganisms</div> <div>3. Microscopical identification of Microorganisms (algae, bacteria and fungi)</div> <div>4. Measurement of growth of microorganisms,</div> <div>5. Analysis of air borne microorganisms,</div> <div>6. Staining of bacteria.</div> <div>7. Effect of pH, temperature on microbial growth</div> <div>8. Bacteriological analysis of wastewater (Coliforms, <i>E.coli</i>, <i>Streptococcus</i>) – MPN</div> <div>9. Bacteriological analysis of wastewater (Coliforms, <i>Streptococcus</i>) - MF techniques.</div> <div>10. Effect of Heavy metals on microbial growth.</div> <div>11. Detection of Anaerobic bacteria (<i>Clostridium</i> sp.)</div> <div>12. Bioreactors (cultivation of microorganisms)</div> |  |                                                                                                |   |   |   |        |
| OUTCOMES:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |                                                                                                |   |   |   |        |
| CO 1: Ability to calibrate and standardize the equipments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |                                                                                                |   |   |   |        |
| CO 2: Ability to collect proper sample for analysis                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |  |                                                                                                |   |   |   |        |
| CO 3: The candidate ability to perform field oriented testing of water, wastewater and soil                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |  |                                                                                                |   |   |   |        |
| CO 4: Able to perform soil testing                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |  |                                                                                                |   |   |   |        |
| CO 5: Able to perform analysis of water and wastewater                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |  |                                                                                                |   |   |   |        |
| REFERENCES:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |  |                                                                                                |   |   |   |        |
| <div>1. APHA. "Standard Methods for the Examination of Water and Wastewater", 22nd Ed. Washington, 2012.</div> <div>2. "Laboratory Manual for the Examination of water, wastewater soil Rump", H.H. and Krist. H. – Second Edition, VCH, Germany, 3rd Edition, 1999.</div> <div>3. "Methods of air sampling &amp; analysis", James P.Lodge Jr(Editor) 3rd Edition, Lewis publishers, Inc, USA, 1989.</div>                                                                                                                                                                                                                                                                                                                                                                                                                |  |                                                                                                |   |   |   |        |

  
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| Mapping of COs with POs and PSOs                                 |     |     |     |      |      |      |
|------------------------------------------------------------------|-----|-----|-----|------|------|------|
| COs/POs                                                          | PO1 | PO2 | PO3 | PSO1 | PSO2 | PSO3 |
| CO1                                                              | 2   | -   | 3   | 2    | 2    | 1    |
| CO2                                                              | 1   | 1   | 3   | 3    | 1    | 1    |
| CO3                                                              | 1   | 1   | 3   | 3    | 2    | 1    |
| CO4                                                              | 1   | 1   | 3   | 3    | 1    | 1    |
| CO5                                                              | 1   | 1   | 3   | 3    | 2    | 1    |
| Avg.                                                             | 1   | 1   | 3   | 3    | 3    | 1    |
| 1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom's Taxonomy |     |     |     |      |      |      |

  
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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                  |                                                                                                                                                                       |   |   |   |        |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|--------|
| PEVL2402                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                  | ENVIRONMENTAL MICROBIOLOGY LABORATORY                                                                                                                                 |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                  | Category                                                                                                                                                              | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                  | PCC                                                                                                                                                                   | 0 | 0 | 4 | 2      |
| Course objectives                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                  | To train the students in the analysis of various microbiological techniques, microbiological analysis, enzyme assay, pollutant analysis and operation of bioreactors. |   |   |   |        |
| LIST OF EXPERIMENTS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                  |                                                                                                                                                                       |   |   |   |        |
| <ol style="list-style-type: none"> <li>1. Preparation of culture media,</li> <li>2. Isolation and culturing of microorganisms</li> <li>3. Microscopical identification of Microorganisms (algae, bacteria and fungi)</li> <li>4. Measurement of growth of microorganisms,</li> <li>5. Analysis of air borne microorganisms,</li> <li>6. Staining of bacteria.</li> <li>7. Effect of pH, temperature on microbial growth</li> <li>8. Bacteriological analysis of wastewater (Coliforms, <i>E.coli</i>, <i>Streptococcus</i>) – MPN</li> <li>9. Bacteriological analysis of wastewater (Coliforms, <i>Streptococcus</i>) - MF techniques,</li> <li>10. Effect of Heavy metals on microbial growth.</li> <li>11. Detection of Anaerobic bacteria (<i>Clostridium</i> sp.)</li> <li>12. Bioreactors (cultivation of microorganisms)</li> </ol> |                                                                                                                                                                                                  |                                                                                                                                                                       |   |   |   |        |
| OUTCOMES:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                  |                                                                                                                                                                       |   |   |   |        |
| <ul style="list-style-type: none"> <li>On completion of the course, the student is expected to be able to</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                  |                                                                                                                                                                       |   |   |   |        |
| CO1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Explain the basic importance and functional elements of environmental microbiology including the types of microorganisms in air, water and soil.                                                 |                                                                                                                                                                       |   |   |   |        |
| CO2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Understand and describe the type of microorganisms in the environment, their importance and the method of culturing of microorganisms in the laboratory.                                         |                                                                                                                                                                       |   |   |   |        |
| CO3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Understand the basic biochemical method of identification of microorganisms and to identify them using microscopical tool.                                                                       |                                                                                                                                                                       |   |   |   |        |
| CO4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Select and apply appropriate methods for detection in the water, air and soil borne pathogens, their health implications, importance of microbes in our daily life.                              |                                                                                                                                                                       |   |   |   |        |
| CO5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Conduct testing and research on toxicology, the importance of test organisms, environmental applications of such microorganisms in toxicological studies and in developing risk based standards. |                                                                                                                                                                       |   |   |   |        |
| REFERENCES:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                  |                                                                                                                                                                       |   |   |   |        |
| <ol style="list-style-type: none"> <li>1. APHA. "Standard Methods for the Examination of Water and Wastewater", 22nd Ed. Washington, 2012</li> <li>2. Charles P. Gerba. "Environmental Microbiology: A laboratory manual", Elsevier Publications, 2012.</li> <li>3. Christon J. Hurst, Ronald L. Crawford, Jay L. Garland, David A. Lipson, Aaron L. Mills, and Linda D. Stetzenbach. "Manual of Environmental Microbiology", 3rd Edition, ASM Press, 2007.</li> </ol>                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                  |                                                                                                                                                                       |   |   |   |        |

  
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| Mapping of COs with POs and PSOs |     |     |     |      |      |      |
|----------------------------------|-----|-----|-----|------|------|------|
| COs/POs                          | PO1 | PO2 | PO3 | PSO1 | PSO2 | PSO3 |
| CO1                              | 2   | -   | 3   | 2    | 2    | 1    |
| CO2                              | 1   | 1   | 3   | 3    | 1    | 1    |
| CO3                              | 1   | 1   | 3   | 3    | 2    | 1    |
| CO4                              | 1   | 1   | 3   | 3    | 1    | 1    |
| CO5                              | 1   | 1   | 3   | 3    | 2    | 1    |
| Avg.                             | 1   | 1   | 3   | 3    | 3    | 1    |

1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom's Taxonomy

  
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|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|---|---|---|--------|
| PEVT2421                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | BIOLOGICAL TREATMENT PROCESS FOR WASTEWATER                                                                                                                                                                                                                                                                                           |          |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                       | Category | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                       | PCC      | 3 | 0 | 0 | 3      |
| Course objectives                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                       |          |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <ul style="list-style-type: none"><li>To educate the students on the principles and process designs of various treatment systems for wastewater</li><li>To gain competency in the process employed in design of treatment systems and the components comprising such systems, leading to the selection of specific process.</li></ul> |          |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | REACTION KINETICS AND BIO REACTORS                                                                                                                                                                                                                                                                                                    |          |   |   |   | 9      |
| Objectives of biological treatment – significance – principles of aerobic and anaerobic treatment - kinetics of biological growth – factors affecting growth – attached and suspended growth - determination of kinetic coefficients for organics removal - enzyme kinetics biodegradability assessment - selection of process-reactors- biokinetics - batch reactor - continuous flow stirred tank reactor-plug flow reactor - flow charts, layout, PID, hydraulic profile |                                                                                                                                                                                                                                                                                                                                       |          |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | CONVENTIONAL AEROBIC TREATMENT PROCESSES                                                                                                                                                                                                                                                                                              |          |   |   |   | 9      |
| Design of sewage treatment plant units –activated sludge process and variations - trickling filters- bio-tower- RBC- fluidized bed reactors, aerated lagoons, waste stabilization ponds – natural treatment systems, constructed wetland – nutrient removal systems- disposal options – reclamation and reuse – recent trends.                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                       |          |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | ADVANCED AEROBIC TREATMENT PROCESSES OF WASTEWATER                                                                                                                                                                                                                                                                                    |          |   |   |   | 9      |
| Sequencing batch reactors- moving bed biofilm reactors- membrane bioreactor- reclamation and reuse of wastewater-design of tertiary treatment units-application of membrane separation technologies in reuse of sewage -nutrient removal systems-case studies                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                       |          |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | ANAEROBIC TREATMENT OF WASTEWATER                                                                                                                                                                                                                                                                                                     |          |   |   |   | 9      |
| Attached and suspended growth process - design of units – UASB – post treatment systems for UASB reactor-anaerobic filters – expanded bed and fluidized bed anaerobic systems - septic tank and soil disposal system - anaerobic baffled reactor – design of nutrient removal systems - anaerobic ammonium oxidation process - recent trends.                                                                                                                               |                                                                                                                                                                                                                                                                                                                                       |          |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | SLUDGE TREATMENT, OPERATION AND MAINTENANCE                                                                                                                                                                                                                                                                                           |          |   |   |   | 9      |
| Sources and its characteristics-design of sludge management facilities, sludge thickening- sludge digestion - biogas generation- sludge dewatering- mechanical – ultimate residue disposal – recent advances-construction and operational maintenance problems in STPs– trouble shooting – planning, organizing and controlling of plant operations - capacity building - retrofitting case studies                                                                         |                                                                                                                                                                                                                                                                                                                                       |          |   |   |   |        |
| Total: 45 periods                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                       |          |   |   |   |        |
| REFERENCES:                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                       |          |   |   |   |        |
| 1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Arceivala S.J., and Asolekar S.R "Wastewater Treatment for Pollution Control and reuse "McGraw Hill . third Edition, New Delhi, 2007.                                                                                                                                                                                                 |          |   |   |   |        |

  
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2. Manual for "Sewerage and Sewage Treatment Systems" CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 2013.
3. Metcalf & Eddy, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater engineering, treatment and reuse, Fourth Edition, McGraw-Hill, 2017
4. Qasim, S. R. and Guang Zhu "Wastewater Treatment and Reuse, Theory and Design Examples", CRC Press, New York, 2018.
5. F.R. Spellman, "Hand Book of Water and Wastewater Treatment Plant operations", CRC Press, New York 2009.
6. David Hendricks, "Fundamentals of Water Treatment Process", CRC Press, New York 2011.

**COURSE OUTCOMES:**

On completion of the course, the student is expected to be able to

**BT Mapped  
(Highest Level)**

|     |                                                                                                                                               |    |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------|----|
| CO1 | Understand the microbial process and its kinetics                                                                                             | K2 |
| CO2 | Design and size the different components of conventional aerobic treatment systems.                                                           | K2 |
| CO3 | Design and size the different components of advanced aerobic treatment systems.                                                               | K2 |
| CO4 | Understand in detail about the anaerobic treatment of wastewater which includes the design of attached and suspended growth processes.        | K2 |
| CO5 | Design the different elements of sludge treatment systems and understand the importance O&M issues pertaining to biological treatment systems | K2 |

**Mapping of COs with POs and PSOs**

| COs/<br>POs | P<br>O<br>1 | PO2 | PO3 | PSO1 | PSO2 | SPO3 |
|-------------|-------------|-----|-----|------|------|------|
| CO1         | 2           | -   | 3   | 2    | 1    | 1    |
| CO2         | 3           | 3   | 3   | 2    | 1    | 1    |
| CO3         | 3           | 3   | 3   | 2    | 1    | 1    |
| CO4         | 3           | 2   | 3   | 2    | 2    | 2    |
| CO5         | 2           | 2   | 3   | 3    | 2    | 3    |
| Avg.        | 3           | 2   | 3   | 2    | 1    | 2    |

  
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|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|---|---|---|--------|
| PEVT2422                                                                                                                                                                                                                                                                                                                                                                                               | AIR AND NOISE POLLUTION CONTROL ENGINEERING                                                          |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                        | Category                                                                                             | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                                                                                                                        | PCC                                                                                                  | 3 | 0 | 0 | 3      |
| Course objectives                                                                                                                                                                                                                                                                                                                                                                                      | To impart knowledge on types and sources of air pollution, its effects and design of control methods |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                                                                                                                                                               | INTRODUCTION                                                                                         |   |   |   | 8      |
| Structure and composition of atmosphere – sources and classification of air pollutants – effects of air pollutants on human health, vegetation & animals, Materials & Structures – effects of air pollutants on the atmosphere, soil & water bodies – Longterm effects– global climate change, Ozone Holes – ambient air quality and emission standards – air pollution indices – emission inventories |                                                                                                      |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                                                                                                                                                              | AIR POLLUTION MONITORING AND MODELLING                                                               |   |   |   | 8      |
| Ambient and stack sampling and analysis of particulate and gaseous pollutants -effects of meteorology on air pollution - fundamentals, atmospheric stability, inversion, wind profiles and stack plume patterns- transport & dispersion of air pollutants – modelling techniques – Air Pollution climatology                                                                                           |                                                                                                      |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                                                                                                                                                             | CONTROL OF PARTICULATE POLLUTANTS                                                                    |   |   |   | 10     |
| Factors affecting selection of control equipment; gas particle interaction, – working principle, design and performance equations of gravity separators, cyclones, Fabric filters, particulate scrubbers, electrostatic precipitators – operational considerations - costing of APC equipment – recent advances                                                                                        |                                                                                                      |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                                                                              | CONTROL OF GASEOUS POLLUTANTS                                                                        |   |   |   | 10     |
| Factors affecting selection of control equipment -working principle, design and performance equations of absorption, adsorption, condensation, incineration, bio-scrubbers, bio-filters –control technologies- SO <sub>2</sub> , NO <sub>x</sub> , CO, H <sub>2</sub> S: process control and monitoring - operational considerations - costing of APC equipment –emerging trends,                      |                                                                                                      |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                                                                                                                                                                               | AUTOMOBILE AND NOISE POLLUTION                                                                       |   |   |   | 9      |
| <b>Vehicular Pollution:</b> Automobile emission- types of emissions- prevention and control of vehicular pollution.<br><b>Noise Pollution:</b> Sources and effects of noise pollution – measurement – standards –control and preventive measures.<br><b>Indoor Air Pollution:</b> Sources and effects –control and preventive measures                                                                 |                                                                                                      |   |   |   |        |
| Total: 45 periods                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                      |   |   |   |        |
| REFERENCES:                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                      |   |   |   |        |
| 1.                                                                                                                                                                                                                                                                                                                                                                                                     | Noel de Nevers, "Air Pollution Control Engg", McGraw Hill, New York, 2016.                           |   |   |   |        |
| 2.                                                                                                                                                                                                                                                                                                                                                                                                     | Daniel Vallero "Fundamentals of Air Pollution", Fourth Edition, 2008.                                |   |   |   |        |
| 3.                                                                                                                                                                                                                                                                                                                                                                                                     | Arthur C.Stern, "Air Pollution (Vol.I – Vol.VIII)", Academic Press, 2006.                            |   |   |   |        |

  
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|    |                                                                                                       |
|----|-------------------------------------------------------------------------------------------------------|
| 4. | Lawrence K. Wang, Norman C. Pareira, Yung Tse Hung, "Air Pollution Control Engineering", Tokyo, 2004. |
| 5. | David H.F. Liu, Bela G. Liptak, "Air Pollution", Lewis Publishers, 2000.                              |
| 6. | Wayne T. Davis, "Air Pollution Engineering Manual", John Wiley & Sons, Inc., 2000.                    |

**COURSE OUTCOMES:**

After completion of this course, the student is expected to be able to understand:

**BT Mapped  
(Highest Level)**

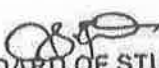
|     |                                                                                          |    |
|-----|------------------------------------------------------------------------------------------|----|
| CO1 | Various types and sources of air pollution and its effects                               | K2 |
| CO2 | Methods of source and ambient monitoring and dispersion of pollutants and their modeling | K2 |
| CO3 | The principles and design of control of particulate pollutants                           | K2 |
| CO4 | The principles and design of control of gaseous pollutant                                | K2 |
| CO5 | Sources, effects and control of vehicular, indoor air and noise pollution                | K2 |

**Mapping of COs with POs and PSOs**

| COs/POs | PO1 | PO2 | PO3 | PSO1 | PSO2 | SPQ3 |
|---------|-----|-----|-----|------|------|------|
| CO1     | 2   | 2   | 3   | 3    | 3    | 2    |
| CO2     | 3   | 2   | 3   | 2    | 2    | 2    |
| CO3     | 3   | 2   | 3   | 3    | 2    | 2    |
| CO4     | 3   | 2   | 3   | 3    | 2    | 2    |
| CO5     | 3   | 2   | 3   | 2    | 2    | 2    |
| Avg.    | 3   | 2   | 3   | 3    | 2    | 2    |

  
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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                           |   |   |   |        |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|--------|
| PEVT2423                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | INDUSTRIAL WASTEWATER POLLUTION – PREVENTION AND CONTROL                                                                                                                                                                                                                                                                                                                                                                                                  |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Category                                                                                                                                                                                                                                                                                                                                                                                                                                                  | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | PCC                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 3 | 0 | 0 | 3      |
| Course objectives                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <ul style="list-style-type: none"><li>• To understand the principle of various processes applicable to industrial wastewater treatment</li><li>• To impart knowledge on the concept and application of Industrial pollution prevention, cleaner technologies, industrial wastewater treatment and residue management.</li><li>• To identify the best applicable technologies for wastewater treatment from the perspective of yield production.</li></ul> |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | INTRODUCTION                                                                                                                                                                                                                                                                                                                                                                                                                                              |   |   |   | 8      |
| Industrial scenario in India– industrial activity and environment - uses of water by industry – sources and types of industrial wastewater – nature and origin of pollutants - industrial wastewater and environmental impacts – regulatory requirements for treatment of industrial wastewater – industrial waste survey – industrial wastewater monitoring and sampling - generation rates, characterization and variables – toxicity of industrial effluents and bioassay tests – major issues on water quality management. |                                                                                                                                                                                                                                                                                                                                                                                                                                                           |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | INDUSTRIAL POLLUTION PREVENTION & WASTE MINIMISATION                                                                                                                                                                                                                                                                                                                                                                                                      |   |   |   | 8      |
| Prevention vis a vis control of industrial pollution – benefits and barriers – waste management Hierarchy -source reduction techniques– periodic waste minimisation assessments–evaluation of pollution prevention options –cost benefit analysis– pay-back period –implementing & promoting pollution prevention programs in industries.                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                           |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | INDUSTRIAL WASTEWATER TREATMENT                                                                                                                                                                                                                                                                                                                                                                                                                           |   |   |   | 10     |
| Flow and load equalisation – solids separation – removal of fats, oil & grease- neutralisation- removal of inorganic constituents – precipitation, heavy METAL removal, nitrogen & phosphorous removal, Ion exchange, adsorption, membrane filtration, electro dialysis & evaporation – removal of organic constituents – biological treatment processes, chemical oxidation processes, advanced oxidation processes – treatability studies                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                           |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | WASTEWATER REUSE AND RESIDUAL MANAGEMENT                                                                                                                                                                                                                                                                                                                                                                                                                  |   |   |   | 9      |
| Individual and common effluent treatment plants – Joint treatment of industrial and domestic wastewater - zero effluent discharge systems - quality requirements for wastewater reuse industrial reuse, present status and issues - disposal on water and land – residuals of industrial wastewater treatment – quantification and characteristics of sludge – thickening, digestion, conditioning, dewatering and disposal of sludge – management of RO rejects.                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                           |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | CASE STUDIES                                                                                                                                                                                                                                                                                                                                                                                                                                              |   |   |   | 10     |
| Industrial manufacturing process description, wastewater characteristics, source reduction options and waste treatment flow sheet for textiles – tanneries – pulp and paper – metal finishing – Oil refining–pharmaceuticals– sugar and distilleries                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                           |   |   |   |        |
| Total: 45 periods                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                           |   |   |   |        |

  
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**REFERENCES:**

|    |                                                                                                                                                                     |
|----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. | "Industrial wastewater management, treatment & disposal, Water Environment Federation Alexandria Virginia, Third Edition, 2008.                                     |
| 2. | Lawrance K. Wang, Yung Tse Hung, Howard H.Lo and Constantine Yapijakis "handbook of Industrial and Hazardous waste Treatment", Second Edition, 2004.                |
| 3. | Metcalf & Eddy, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater engineering, treatment and reuse, Fourth Edition, McGraw-Hill, 2017 |
| 4. | Nelson Leonard Nemerow, " industrial waste Treatment", Elsevier, 2007.                                                                                              |
| 5. | Wesley Eckenfelder W., " Industrial Water Pollution Control", Second Edition, Mc Graw Hill, 2000.                                                                   |
| 6. | Paul L. Bishop, Pollution Prevention: - Fundamentals and Practice", Mc-Graw Hill International, Boston, 2000.                                                       |
| 7. | Waste water Treatment for pollution control and reuse by Soli. J. Arceivala, Shyam, R. Asolekar, Tata McGraw Hill, 2007.                                            |

**COURSE OUTCOMES:**

| On Completion of the course, the student is expected to be able to |                                                                                                                                                              | BT Mapped<br>(Highest Level) |
|--------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
| CO1:                                                               | Explain the source and types of industrial wastewater and their environmental impacts and choose the regulatory laws pertaining to environmental protection  | K2                           |
| CO2:                                                               | Identify industrial wastewater pollution and implement pollution prevention, wasteminimization in industries.                                                | K2                           |
| CO3:                                                               | Apply knowledge and skills to design industrial wastewater treatment schemes                                                                                 | K4                           |
| CO4:                                                               | Audit and analyze environmental performance of industries to internal, external client, regulatory bodies and design water reuse management techniques       | K2                           |
| CO5:                                                               | Conduct research to develop effective management systems for industrial wastewater that are technically sound, economically feasible and socially acceptable | K2                           |

**Mapping of COs with POs and PSOs**

| COs/POs | PO1 | PO2 | PO3 | PSO1 | PSO2 | PSO3 |
|---------|-----|-----|-----|------|------|------|
| CO1     | 2   | 2   | 3   | 2    | 2    | 2    |
| CO2     | 3   | 2   | 3   | 2    | 1    | 1    |
| CO3     | 3   | 2   | 3   | 2    | 2    | 3    |
| CO4     | 2   | 3   | 3   | 2    | 2    | 3    |
| CO5     | 3   | 3   | 2   | 2    | 2    | 4    |
| Avg.    | 3   | 2   | 3   | 2    | 2    | 2    |

1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom's Taxonomy

  
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|                                                              |                                                                                                                                                                     |                                                                                                                                    |   |   |                           |        |
|--------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|---|---|---------------------------|--------|
| PEVL2421                                                     |                                                                                                                                                                     | ENVIRONMENTAL AND PROCESSES MONITORING LABORATORY                                                                                  |   |   |                           |        |
|                                                              |                                                                                                                                                                     | Category                                                                                                                           | L | T | P                         | Credit |
|                                                              |                                                                                                                                                                     | PCC                                                                                                                                | 0 | 0 | 6                         | 3      |
| Course objectives                                            |                                                                                                                                                                     | • To develop the skill for conducting treatability studies of water and wastewater and monitoring of ambient air and noise quality |   |   |                           |        |
|                                                              |                                                                                                                                                                     |                                                                                                                                    |   |   |                           |        |
| Sl. No.                                                      | Name of Experiment                                                                                                                                                  |                                                                                                                                    |   |   |                           | Hours  |
| 1.                                                           | Coagulation and Flocculation                                                                                                                                        |                                                                                                                                    |   |   |                           | 6      |
| 2.                                                           | Batch studies on settling                                                                                                                                           |                                                                                                                                    |   |   |                           | 6      |
| 3.                                                           | Studies on Filtration- Characteristics of Filter media                                                                                                              |                                                                                                                                    |   |   |                           | 6      |
| 4.                                                           | Water softening                                                                                                                                                     |                                                                                                                                    |   |   |                           | 6      |
| 5.                                                           | Adsorption studies/Kinetics                                                                                                                                         |                                                                                                                                    |   |   |                           | 6      |
| 6.                                                           | Langelier Saturation Index and Silt Density Index- For Membrane Filtration                                                                                          |                                                                                                                                    |   |   |                           | 6      |
| 7.                                                           | Kinetics of suspended growth process (activated sludge process)-and Sludge volume Index                                                                             |                                                                                                                                    |   |   |                           | 12     |
| 8.                                                           | Sludge Filterability Test                                                                                                                                           |                                                                                                                                    |   |   |                           | 6      |
| 9.                                                           | Anaerobic Reactor systems / kinetics (Demonstration)                                                                                                                |                                                                                                                                    |   |   |                           | 6      |
| 10.                                                          | Advanced Oxidation Processes – (Photo catalysis)                                                                                                                    |                                                                                                                                    |   |   |                           | 6      |
| 11.                                                          | Disinfection for Drinking water (Chlorination)                                                                                                                      |                                                                                                                                    |   |   |                           | 6      |
| 12.                                                          | Ambient Air Sampling-Determination of PM10, PM2.5, SO2 and NO2                                                                                                      |                                                                                                                                    |   |   |                           | 12     |
| 13.                                                          | Noise Monitoring-Determination of Equivalent Noise Level                                                                                                            |                                                                                                                                    |   |   |                           | 6      |
| TOTAL                                                        |                                                                                                                                                                     |                                                                                                                                    |   |   | 90                        |        |
| PERIODS                                                      |                                                                                                                                                                     |                                                                                                                                    |   |   |                           |        |
| Total: 90 periods                                            |                                                                                                                                                                     |                                                                                                                                    |   |   |                           |        |
| COURSE OUTCOMES:                                             |                                                                                                                                                                     |                                                                                                                                    |   |   | BT Mapped (Highest Level) |        |
| After the completion of the course the students will be able |                                                                                                                                                                     |                                                                                                                                    |   |   |                           |        |
| CO1:                                                         | To conduct treatability studies on water and wastewater treatment                                                                                                   |                                                                                                                                    |   |   | K2                        |        |
| CO2:                                                         | To determine the removal / degradation of pollutants from water and wastewater and arrive at kinetics                                                               |                                                                                                                                    |   |   | K2                        |        |
| CO3:                                                         | To design scaled up reactors for treatment of water and wastewater treatment based on laboratory studies                                                            |                                                                                                                                    |   |   | K2                        |        |
| CO4:                                                         | To determine ambient air quality of given study area in terms of Particulate and Gaseous Pollutants                                                                 |                                                                                                                                    |   |   | K2                        |        |
| CO5:                                                         | To determine Equivalent Noise Level by noise monitoring                                                                                                             |                                                                                                                                    |   |   | K2                        |        |
| REFERENCES:                                                  |                                                                                                                                                                     |                                                                                                                                    |   |   |                           |        |
| 1.                                                           | Metcalf & Eddy, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater engineering, treatment and reuse, Fourth Edition, McGraw-Hill, 2017 |                                                                                                                                    |   |   |                           |        |
| 2.                                                           | Lee, C.C. and Shundar Lin, "Handbook of Environmental Engineering Calculations", McGraw Hill, New York, 1999.                                                       |                                                                                                                                    |   |   |                           |        |

  
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|------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|------|------|------|
| 3.                                                               | AEESP Environmental Processes Laboratory Manual, Association of Environmental Engineering and Science Professors Foundation, Washington, 2002.                            |     |     |      |      |      |
| 4.                                                               | Aery N.C., "Manual of Environmental Analysis", Ane Books Pvt. Ltd. New Delhi, 2014.                                                                                       |     |     |      |      |      |
| 5.                                                               | CPCB, Guidelines for the Measurement of Ambient Air Pollutants, Volume I, Central Pollution Control Board, Ministry of Environment and Forests, Government of India, 2001 |     |     |      |      |      |
| Mapping of COs with POs and PSOs                                 |                                                                                                                                                                           |     |     |      |      |      |
| COs/POs                                                          | PO1                                                                                                                                                                       | PO2 | PO3 | PSO1 | PSO2 | PSO3 |
| CO1                                                              | 2                                                                                                                                                                         | 1   | 3   | 3    | 2    | 1    |
| CO2                                                              | 3                                                                                                                                                                         | 2   | 3   | 2    | 1    | 1    |
| CO3                                                              | 3                                                                                                                                                                         | 2   | 3   | 2    | 2    | 2    |
| Avg.                                                             | 3                                                                                                                                                                         | 2   | 3   | 2    | 2    | 1    |
| 1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom's Taxonomy |                                                                                                                                                                           |     |     |      |      |      |

  
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|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|---|---|-------------------|--------|
| PEVL2431                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | TECHNICAL SEMINAR                                                                                                                                                                                                                                  |          |   |   |                   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                    | Category | L | T | P                 | Credit |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                    | BSC/ESC  | 0 | 0 | 2                 | 1      |
| Course objectives                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                    |          |   |   |                   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <ul style="list-style-type: none"><li>• To work on a specific technical topic in Environmental Engineering and acquire the skills of written and oral presentation.</li><li>• To acquire writing abilities for seminars and conferences.</li></ul> |          |   |   |                   |        |
| SYLLABUS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                    |          |   |   |                   |        |
| The students will work for two hours per week guided by a group of staff members. They will be asked to give a presentation on any topic of their choice related to Environmental Engineering and to engage in discussion with the audience. A brief copy of their presentation also should be submitted. Similarly, the students will have to present a seminar of not less than fifteen minutes and not more than thirty minutes on the technical topic. They will defend their presentation. Evaluation will be based on the technical presentation and the report and also on the interaction shown during the seminar. |                                                                                                                                                                                                                                                    |          |   |   |                   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                    |          |   |   | Total: 30 periods |        |

|                                                           |                                                                                                                       |                                  |
|-----------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|----------------------------------|
| <b>COURSE OUTCOMES:</b>                                   |                                                                                                                       | <b>BT Mapped (Highest Level)</b> |
| On completion of the course, the students will be able to |                                                                                                                       |                                  |
| CO                                                        | The students will be trained to face an audience and to tackle any problem during group discussion in the Interviews. | Apply                            |

|                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                   |          |   |   |   |        |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|---|---|---|--------|
| PEVL2432                                                                                                                                                                                                                                                                                                                                                             | INDUSTRIAL TRAINING (2 Weeks)                                                                                                                                                                                                                                                                     |          |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                   | Category | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                   | BSC/ESC  | 0 | 0 | 0 | 1      |
| Course objectives                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                   |          |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                      | <ul style="list-style-type: none"><li>● To train the students in the field work so as to have a firsthand knowledge of practical problems related to Environmental Engineering in carrying out engineering tasks.</li><li>● To develop skills in facing and solving the field problems.</li></ul> |          |   |   |   |        |
| SYLLABUS                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                   |          |   |   |   |        |
| The students individually undertake training in reputed Industries during the summer vacation for a specified period of two weeks. At the end of training, a detailed report on the work done should be submitted within ten days from the commencement of the semester. The students will be evaluated through a viva-voce examination by a team of internal staff. |                                                                                                                                                                                                                                                                                                   |          |   |   |   |        |

|                                                           |                                                                                                                  |                                  |
|-----------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|----------------------------------|
| <b>COURSE OUTCOMES:</b>                                   |                                                                                                                  | <b>BT Mapped (Highest Level)</b> |
| On completion of the course, the students will be able to |                                                                                                                  |                                  |
| CO                                                        | They are trained in tackling a practical field/industry orientated problem related to Environmental Engineering. | Apply                            |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                              |          |   |   |    |                    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|---|---|----|--------------------|
| PEVL2433                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | PROJECT WORK I                                                                                                                                                                                                                                                                                                                                                                               |          |   |   |    |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                              | Category | L | T | P  | Credit             |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                              | BSC/ESC  | 0 | 0 | 12 | 6                  |
| Course objectives                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                              |          |   |   |    |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <ul style="list-style-type: none"><li>● To identify a specific problem for the current need of the society and collecting information related to the same through detailed review of literature.</li><li>● To develop the methodology to solve the identified problem.</li><li>● To train the students in preparing project reports and to face reviews and viva-voce examination.</li></ul> |          |   |   |    |                    |
| SYLLABUS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                              |          |   |   |    |                    |
| The student individually works on a specific topic approved by faculty member who is familiar in this area of interest. The student can select any topic which is relevant to his/her specialization of the programme. The topic may be experimental or analytical or case studies. At the end of the semester, a detailed report on the work done should be submitted which contains clear definition of the identified problem, detailed literature review related to the area of work and methodology for carrying out the work. The students will be evaluated through a viva-voce examination by a panel of examiners including one external examiner. |                                                                                                                                                                                                                                                                                                                                                                                              |          |   |   |    |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                              |          |   |   |    | Total: 180 periods |

|                                                           |                                                                                                                                                                               |                                  |
|-----------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|
| <b>COURSE OUTCOMES:</b>                                   |                                                                                                                                                                               | <b>BT Mapped (Highest Level)</b> |
| On completion of the course, the students will be able to |                                                                                                                                                                               |                                  |
| CO                                                        | At the end of the course the students will have a clear idea of his/her area of work and they are in a position to carry out the remaining phase II work in a systematic way. | Evaluate                         |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                   |          |   |   |    |        |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|---|---|----|--------|
| PEVL2441                                                                                                                                                                                                                                                                                                                                                                                                                                                    | PROJECT WORK II                                                                                                                                                                                                   |          |   |   |    |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                   | Category | L | T | P  | Credit |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                   | BSC/ESC  | 0 | 0 | 24 | 12     |
| Course objectives                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                   |          |   |   |    |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <ul style="list-style-type: none"><li>• To solve the identified problem based on the formulated methodology.</li><li>• To develop skills to analyze and discuss the test results, and make conclusions.</li></ul> |          |   |   |    |        |
| SYLLABUS                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                   |          |   |   |    |        |
| The student should continue the phase I work on the selected topic as per the formulated methodology. At the end of the semester, after completing the work to the satisfaction of the supervisor and review committee, a detailed report should be prepared and submitted to the head of the department. The students will be evaluated through based on the report and the viva-voce examination by a panel of examiners including one external examiner. |                                                                                                                                                                                                                   |          |   |   |    |        |
| Total: 360 periods                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                   |          |   |   |    |        |

|                                                           |                                                                                                                                          |                                  |
|-----------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|
| <b>COURSE OUTCOMES:</b>                                   |                                                                                                                                          | <b>BT Mapped (Highest Level)</b> |
| On completion of the course, the students will be able to |                                                                                                                                          |                                  |
| CO                                                        | On completion of the project work students will be in a position to take up any challenging practical problem and find better solutions. | Create                           |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                              |   |   |   |        |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|--------|
| PEVE2401                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | SOLID AND HAZARDOUS WASTE MANAGEMENT                                                                                                                                                                                                                                                                         |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Category                                                                                                                                                                                                                                                                                                     | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | PEC                                                                                                                                                                                                                                                                                                          | 3 | 0 | 0 | 3      |
| Course objectives                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <ul style="list-style-type: none"><li>To impart knowledge and skills relevant to minimization, storage, collection, transport, recycling, processing and disposal of solid and hazardous wastes including the related regulations, engineering principles, design criteria, methods and equipment.</li></ul> |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | WASTE CLASSIFICATION AND REGULATORY REQUIREMENTS                                                                                                                                                                                                                                                             |   |   |   | 9      |
| Sources and types of solid and hazardous wastes - need for solid and hazardous waste management – salient features of latest Indian legislations on management and handling of solid wastes, hazardous wastes, biomedical wastes, electronic wastes, construction and demolition wastes, plastics and discarded lead acid batteries – elements of integrated waste management and roles of stakeholders - seven elements and seven step approach to integrated solid waste management planning.                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                              |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | WASTE CHARACTERIZATION, SOURCE REDUCTION AND RECYCLING                                                                                                                                                                                                                                                       |   |   |   | 9      |
| Waste sampling and characterization plan - waste generation rates and variation – physical composition, chemical and biological properties – hazardous characteristics – ignitability, corrosivity and TCLP tests – source reduction, segregation and onsite storage of wastes – waste exchange - extended producer responsibility - recycling of plastics, C&D wastes and E wastes.                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                              |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | WASTE COLLECTION, TRANSPORT AND MATERIAL RECOVERY                                                                                                                                                                                                                                                            |   |   |   | 9      |
| Door to door collection of segregated solid wastes - analysis of hauled container and stationery container collection systems - compatibility, storage, labeling and handling of hazardous wastes – principles and design of transfer and transport facilities - hazardous waste transport and manifests- mechanical processing and material separation technologies – Size reduction – size separation – density separation - magnetic separation – compaction – principles and design of material recovery facilities – physico chemical treatment of hazardous wastes - solidification and stabilization – case studies on waste collection and material recovery |                                                                                                                                                                                                                                                                                                              |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | BIOLOGICAL AND THERMAL PROCESSING OF WASTES                                                                                                                                                                                                                                                                  |   |   |   | 9      |
| Biological and thermo chemical conversion technologies – composting – biomethanation – incineration – pyrolysis- plasma arc gasification –principles and design of biological and thermal treatment facilities- MSW processes to energy with high-value products and specialty BY-Products- operation of facilities and environmental controls - treatment of biomedical wastes – case studies and emerging waste processing technologies.                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                              |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | WASTE DISPOSAL                                                                                                                                                                                                                                                                                               |   |   |   | 9      |
| Sanitary and secure landfills - components and configuration– site selection - liner and cover systems - geo synthetic clay liners and geo membranes - design of sanitary landfills and secure landfills- leachate collection, treatment and landfill gas management – landfill construction and operational controls - landfill closure and environmental monitoring – landfill bioreactors – rehabilitation of open dumps and biomining of dumpsites-remediation of contaminated sites- Case studies                                                                                                                                                               |                                                                                                                                                                                                                                                                                                              |   |   |   |        |

  
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|                    |                                                                                                                                                                                    |                   |
|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
|                    |                                                                                                                                                                                    | Total: 45 periods |
| <b>REFERENCES:</b> |                                                                                                                                                                                    |                   |
| 1.                 | George Tehobanoglous, Hilary Theisen and Samuel A. Vigil, "Integrated Solid Waste Management. McGraw Hill India. First edition, 2015.                                              |                   |
| 2.                 | CPHEEO, "Manual on Municipal Solid waste management, Vol I, II and III, Central Public Health and Environmental Engineering Organisation, Government of India, New Delhi, 2016.    |                   |
| 3.                 | William A. Worrell, P. Arne Vesilind, Christian Ludwig, Solid Waste Engineering - A Global Perspective, 3rd Edition, Cengage Learning, 2017.                                       |                   |
| 4.                 | Michael D. LaGrega, Philip L Buckingham, Jeffrey C. Evans and "Environmental Resources Management, Hazardous waste Management", McGraw Hill International edition, New York, 2010. |                   |
| 5.                 | John Pichtel, Waste Management Practices, CRC Press, Taylor and Francis Group, 2014.                                                                                               |                   |
| 6.                 | Gary C. Young, Municipal Solid Waste to Energy Conversion Processes: Economic, Technical, and Renewable Comparisons, Wiley, 2010.                                                  |                   |
| 7.                 | Cherry P M. Solid and Hazardous Waste Management, CBS publishers and distributors Pvt Ltd, 2018                                                                                    |                   |
| 8.                 | Rao M.N. Razia Sultana, Sri Harsha Kota, solid and hazardous waste management – Science and Engineering, Butterworth-Heinemann, 2016.                                              |                   |

| <b>COURSE OUTCOMES:</b>                                            |                                                                                                                                                                                                                                  | BT Mapped<br>(Highest Level) |
|--------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
| On completion of the course, the student is expected to be able to |                                                                                                                                                                                                                                  |                              |
| CO1:                                                               | Explain the various functional elements of solid and hazardous waste management including the associated legal, health, safety, and cultural issues as well as responsibilities of different stakeholders                        | K2                           |
| CO2:                                                               | Apply the knowledge of science and engineering fundamentals to characterize different types of solid and hazardous wastes, assess the factors affecting variation and assess performance of waste treatment and disposal systems | K2                           |
| CO3:                                                               | Design of systems and processes to meet specified needs of waste minimization, storage, collection, transport, recycling, processing and disposal.                                                                               | K2                           |
| CO4:                                                               | Select appropriate methods for processing and disposal of solid and hazardous wastes, taking into account the impact of the solutions in a sustainability context                                                                | K2                           |
| CO5:                                                               | Conduct research pertinent to solid and hazardous waste management and communicate effectively to different stakeholders as well as engage in independent life-long learning                                                     | K2                           |

  
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| Mapping of COs with POs and PSOs                                 |     |     |         |      |      |      |
|------------------------------------------------------------------|-----|-----|---------|------|------|------|
| COs/<br>POs                                                      | PO1 | PO2 | PO<br>3 | PSO1 | PSO2 | PSO3 |
| CO1                                                              | 1   | 1   | 3       | 2    | 3    | 3    |
| CO2                                                              | 2   | 1   | 3       | 2    | 3    | 2    |
| CO3                                                              | 2   | 1   | 3       | 3    | 3    | 1    |
| CO4                                                              | 2   | 2   | 3       | 3    | 2    | 1    |
| CO5                                                              | 3   | 1   | 3       | 3    | 3    | 3    |
| Avg                                                              | 2   | 1   | 3       | 3    | 3    | 2    |
| 1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom's Taxonomy |     |     |         |      |      |      |

  
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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                  |   |   |   |        |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|--------|
| PEVE2402                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | NATURAL SYSTEMS FOR WASTEWATER TREATMENT                                                                                                                                                                                                                                                                                                                         |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Category                                                                                                                                                                                                                                                                                                                                                         | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | PEC                                                                                                                                                                                                                                                                                                                                                              | 3 | 0 | 0 | 3      |
| Course objectives                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                  |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <ul style="list-style-type: none"><li>To gain knowledge and understanding of wetlands -types of wetland, constructed wetland - application, design, method of treatment of both domestic and industrial wastewaters and case studies.</li><li>To gain knowledge on design, construction and operation of waste stabilization pond and sludge disposal.</li></ul> |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | INTRODUCTION TO WETLAND TREATMENT SYSTEM                                                                                                                                                                                                                                                                                                                         |   |   |   | 9      |
| Definition and concept of wetland - types of wetland. Wetland - ecology, flora and fauna, ecological aspects, human health and wetland, onsite applications, introduction to constructed wetland-types-free water surface, subsurface wetland-horizontal and vertical flow- wastewaters and their application in wetland - constructed wetland plants-media – in constructed wetland.                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                  |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | CONSTRUCTED WETLAND AND REMOVAL MECHANISMS                                                                                                                                                                                                                                                                                                                       |   |   |   | 9      |
| Site identification- construction and design of constructed wetland, startup, operation and maintenance of wetland system-wetland hydrology- hydraulics. Treatment of domestic wastewater and its performance, mechanisms of pollutant removal- suspended solids, organic matter, nitrogen, phosphorus, pathogen and other contaminants. Reuse of treated wastewater and its applications-limitation of constructed wetland system.                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                  |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | CASE STUDIES ON CONSTRUCTED WETLAND SYSTEM                                                                                                                                                                                                                                                                                                                       |   |   |   | 8      |
| Constructed wetland- treatment of domestic wastewater- greywater - landfill leachate – treatment of industrial wastewaters- textile wastewater – dairy wastewater and its performance. Removal of specific pollutants such as heavy metals, aromatics and emerging contaminants etc. Use of amendments in wetland construction, and its performance. Capital and maintenance costs.                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                  |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | DESIGN OF WASTEWATER POND SYSTEMS.                                                                                                                                                                                                                                                                                                                               |   |   |   | 10     |
| Introduction- facultative -partial -mix aerated- ponds -complete -mix aerated pond systems - anaerobic ponds - nitrogen removal in lagoons. Modified high -performance aerated pond systems for nitrification and denitrification - nitrogen removal in ponds coupled with wetlands and gravel bed nitrification filters -Control of algae and design of settling basins. Hydraulic control of ponds -removal of phosphorous -removal of pharmaceuticals and personal care products and antibiotic resistant genes.                                       |                                                                                                                                                                                                                                                                                                                                                                  |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | SLUDGE MANAGEMENT AND TREATMENT                                                                                                                                                                                                                                                                                                                                  |   |   |   | 9      |
| Sludge quantity and characteristics - stabilization and dewatering -sludge freezing -reed beds - vermi stabilization -comparison of bed type operations -composting land application and surface disposal of bio solids onsite wastewater systems -effluent disposal and reuse. Sludge quantity and characteristics- stabilization and dewatering-sludge freezing reed beds-vermi stabilization- Comparison of bed-type operations-composting land application and surface disposal of biosolids-on-site wastewater systems- effluent disposal and reuse. |                                                                                                                                                                                                                                                                                                                                                                  |   |   |   |        |
| Total: 45 periods                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                  |   |   |   |        |

  
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**REFERENCES:**

|    |                                                                                                                                               |
|----|-----------------------------------------------------------------------------------------------------------------------------------------------|
| 1. | EPA- Design Manual on constructed wetland and aquatic plant system for municipal wastewater treatment system                                  |
| 2. | Treatment wetlands by Robert .H.Kadlec, Scott Wallace , CRC press published July 22, 2008                                                     |
| 3. | Natural Wastewater Treatment Systems, Ronald W. Crites, E. Joe Middlebrooks, Robert K. Bastia, 2nd Edition, CRC PressPublished March 14, 2014 |
| 4. | Waste water treatment in constructed wetlands with horizontal sub- surface flow by Jan Vyamazal and Lenka Kropfelova, Springer 2010.          |
| 5. | Constructed wetlands for industrial wastewater treatment system by Alexandros I.Stefanakis (editor), Wiley black well.2018                    |

**COURSE OUTCOMES:**

On completion of the course, the student is expected to be able to

**BT Mapped  
(Highest Level)**

|      |                                                                                                                                                                                                                                                                                                                                               |    |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| CO1: | Explain the various aspects of wetland system, its function and its application in the treatment of wastewaters.                                                                                                                                                                                                                              | K2 |
| CO2: | Apply the knowledge of science and engineering fundamentals to know the types of wetlands, construction and operation of wetlands, wetland hydraulics and design of wetland and its performance Understand the process of treatment of domestic waste in the removal of solids, organic matter, phosphate, nitrogen, pathogens and its reuse. | K3 |
| CO3: | Understand the process of treatment of industrial wastewater in the removal of solids, organic matter, phosphate, nitrogen, heavy metals, phenolics and feasibility for reuse.                                                                                                                                                                | K2 |
| CO4: | Understand the various pond system available for wastewater treatment. design of pond system -removal mechanism.                                                                                                                                                                                                                              | K2 |
| CO5: | Manage and dispose the sludge naturally and economically.                                                                                                                                                                                                                                                                                     | K2 |

**Mapping of COs with POs and PSOs**

| COs/POs | PO1 | PO2 | PO3 | PsO1 | PsO2 | PsO3 |
|---------|-----|-----|-----|------|------|------|
| CO1     | 2   | 1   | 3   | 3    | 3    | 1    |
| CO2     | 2   | 1   | 3   | 2    | 3    | 1    |
| CO3     | 3   | 1   | 3   | 3    | 3    | 1    |
| CO4     | 2   | 2   | 3   | 2    | 2    | 1    |
| CO5     | 1   | 1   | 3   | 2    | 2    | 1    |
| Avg.    | 2   | 1   | 3   | 2    | 3    | 1    |

1 - Slight, 2 - Moderate, 3 - Substantial, BT - Bloom's Taxonomy

  
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| PEVE2403                                                                                                                                                                                                                                                                                    |                                                                                                        | ENVIRONMENTAL SYSTEM ANALYSIS                                                                                                                                                                                                                                                         |   |   |   |                   |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|-------------------|
|                                                                                                                                                                                                                                                                                             |                                                                                                        | Category                                                                                                                                                                                                                                                                              | L | T | P | Credit            |
|                                                                                                                                                                                                                                                                                             |                                                                                                        | PEC                                                                                                                                                                                                                                                                                   | 3 | 0 | 0 | 3                 |
| Course objectives                                                                                                                                                                                                                                                                           |                                                                                                        |                                                                                                                                                                                                                                                                                       |   |   |   |                   |
|                                                                                                                                                                                                                                                                                             |                                                                                                        | <ul style="list-style-type: none"><li>To introduce the modelling concept in various environmental field like ecological modelling, CSTR modelling and the kinetics of reaction</li><li>To gain knowledge on river and stream water modelling and soft computing techniques.</li></ul> |   |   |   |                   |
| UNIT – I                                                                                                                                                                                                                                                                                    | ECOLOGICAL SYSTEM                                                                                      |                                                                                                                                                                                                                                                                                       |   |   |   | 9                 |
| Basic concepts in ecology and ecological modelling, population dynamics: birth and death processes. Single species growth, prey-predator models: Lotka-Volterra, Rosenzweig-MacArthur, Kolmogorov models. multi-species modeling - structural analysis and stability of complex ecosystems. |                                                                                                        |                                                                                                                                                                                                                                                                                       |   |   |   |                   |
| UNIT – II                                                                                                                                                                                                                                                                                   | REACTOR MODELLING                                                                                      |                                                                                                                                                                                                                                                                                       |   |   |   | 9                 |
| CSTR, plug-flow, dispersion. A case study of a tubular reactor with axial dispersion, parameter calibration; search algorithms for nonlinear dynamical models, variance of estimated parameters, application to Monod and Haldane kinetics.                                                 |                                                                                                        |                                                                                                                                                                                                                                                                                       |   |   |   |                   |
| UNIT – III                                                                                                                                                                                                                                                                                  | WATER QUALITY MODELLING                                                                                |                                                                                                                                                                                                                                                                                       |   |   |   | 9                 |
| Rivers and streams water quality modeling -dispersion and mixing- water quality modelling process-model sensitivity-assessing model performance; models for dissolved oxygen and pathogens-pollutant and nutrient dynamics -dissolved oxygen dynamics -groundwater quality modeling.        |                                                                                                        |                                                                                                                                                                                                                                                                                       |   |   |   |                   |
| UNIT – IV                                                                                                                                                                                                                                                                                   | MICROBIAL DYNAMICS AND ENERGETICS                                                                      |                                                                                                                                                                                                                                                                                       |   |   |   | 9                 |
| Requirements for carbon and nutrient removal. Activated sludge: process schemes: completely mixed, plug-flow, SBR, nutrient removal. Anaerobic digestion: process dynamics, operational control of wastewater treatment processes.                                                          |                                                                                                        |                                                                                                                                                                                                                                                                                       |   |   |   |                   |
| UNIT – V                                                                                                                                                                                                                                                                                    | COMPUTER BASED SOLUTIONS                                                                               |                                                                                                                                                                                                                                                                                       |   |   |   | 9                 |
| Formulation of linear optimization models. linear programming, sensitivity testing and duality. Solution techniques and computer programming; Formulation of linear optimization models. Application of models- simulation, parameter estimation and experimental design.                   |                                                                                                        |                                                                                                                                                                                                                                                                                       |   |   |   |                   |
|                                                                                                                                                                                                                                                                                             |                                                                                                        |                                                                                                                                                                                                                                                                                       |   |   |   | Total: 45 periods |
| REFERENCES:                                                                                                                                                                                                                                                                                 |                                                                                                        |                                                                                                                                                                                                                                                                                       |   |   |   |                   |
| 1.                                                                                                                                                                                                                                                                                          | Deaton, M.L and Winebrake, J.J., "Dynamic Modeling of Environmental Systems". Springer- Verlag, 2000   |                                                                                                                                                                                                                                                                                       |   |   |   |                   |
| 2.                                                                                                                                                                                                                                                                                          | Orhon, D and Artan, N., "Modeling of Activated Sludge Systems, Technomic" Publ. Co., 1994.             |                                                                                                                                                                                                                                                                                       |   |   |   |                   |
| 3.                                                                                                                                                                                                                                                                                          | Steven C. Chapra, "Surface Water Quality Modelling", Tata McGraw-Hill Companies, Inc., New Delhi 2018. |                                                                                                                                                                                                                                                                                       |   |   |   |                   |

  
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| COURSE OUTCOMES:<br>On completion of the course, the students are able to |                                                                              |     |     |      | BT Mapped<br>(Highest Level) |      |
|---------------------------------------------------------------------------|------------------------------------------------------------------------------|-----|-----|------|------------------------------|------|
| CO1:                                                                      | Apply the principle of system modeling                                       |     |     |      | K4                           |      |
| CO2:                                                                      | Do reactor modeling                                                          |     |     |      | K2                           |      |
| CO3:                                                                      | Develop water quality models                                                 |     |     |      | K2                           |      |
| CO4:                                                                      | Model microbial dynamics                                                     |     |     |      | K4                           |      |
| CO5:                                                                      | Apply the knowledge of numerical techniques to environmental system modeling |     |     |      | K2                           |      |
| Mapping of COs with POs and PSOs                                          |                                                                              |     |     |      |                              |      |
| COs/POs                                                                   | PO1                                                                          | PO2 | PO3 | PSO1 | PSO2                         | PSO3 |
| CO 1                                                                      | 1                                                                            | 2   | 3   | 3    | 1                            | 1    |
| CO 2                                                                      | 1                                                                            | 1   | 3   | 3    | 1                            | 1    |
| CO 3                                                                      | 2                                                                            | 1   | 2   | 2    | 1                            | 1    |
| CO 4                                                                      | 2                                                                            | 1   | 3   | 2    | 1                            | 1    |
| CO 5                                                                      | 2                                                                            | 2   | 3   | 2    | 2                            | 1    |
| Av g.                                                                     | 2                                                                            | 1   | 3   | 2    | 1                            | 1    |
| 1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy         |                                                                              |     |     |      |                              |      |

  
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|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|-------------------|
| PEVE2404                                                                                                                                                                                                                                                                                                                                                        | ENVIRONMENTAL IMPACT ASSESSMENT                                                                                                                                                                                                                                         |   |   |   |                   |
|                                                                                                                                                                                                                                                                                                                                                                 | Category                                                                                                                                                                                                                                                                | L | T | P | Credit            |
|                                                                                                                                                                                                                                                                                                                                                                 | PEC                                                                                                                                                                                                                                                                     | 3 | 0 | 0 | 3                 |
| Course objectives                                                                                                                                                                                                                                                                                                                                               | <ul style="list-style-type: none"><li>To make the students to understand environmental clearance, its legal requirements and to provide knowledge on overall methodology of EIA, prediction tools and models, environmental management plan and case studies.</li></ul> |   |   |   |                   |
| UNIT - I                                                                                                                                                                                                                                                                                                                                                        | INTRODUCTION                                                                                                                                                                                                                                                            |   |   |   | 9                 |
| Historical development of Environmental Impact Assessment (EIA). Environmental Clearance- EIA in project cycle, legal and regulatory aspects in India - types and limitations of EIA -EIA process-screening - scoping - terms of reference in EIA- setting - analysis - mitigation. Cross sectoral issues -public hearing in EIA- EIA consultant accreditation. |                                                                                                                                                                                                                                                                         |   |   |   |                   |
| UNIT - II                                                                                                                                                                                                                                                                                                                                                       | IMPACT IDENTIFICATION AND PREDICTION                                                                                                                                                                                                                                    |   |   |   | 10                |
| Matrices - networks - checklists - cost benefit analysis - analysis of alternatives - expert systems in EIA. prediction tools for EIA - mathematical modeling for impact prediction - assessment of impacts - air - water - soil - noise - biological - cumulative impact assessment                                                                            |                                                                                                                                                                                                                                                                         |   |   |   |                   |
| UNIT - III                                                                                                                                                                                                                                                                                                                                                      | SOCIO-ECONOMIC IMPACT ASSESSMENT                                                                                                                                                                                                                                        |   |   |   | 8                 |
| Socio-economic impact assessment - relationship between social impacts and change in community and institutional arrangements. Factors and methodologies- individual and family level impacts. Communities in transition-rehabilitation                                                                                                                         |                                                                                                                                                                                                                                                                         |   |   |   |                   |
| UNIT - IV                                                                                                                                                                                                                                                                                                                                                       | EIA DOCUMENTATION AND ENVIRONMENTAL MANAGEMENT PLAN                                                                                                                                                                                                                     |   |   |   | 9                 |
| Environmental management plan - preparation, implementation and review - mitigation and rehabilitation plans - policy and guidelines for planning and monitoring programmes - post project audit - documentation of EIA findings - ethical and quality aspects of environmental impact assessment                                                               |                                                                                                                                                                                                                                                                         |   |   |   |                   |
| UNIT - V                                                                                                                                                                                                                                                                                                                                                        | CASE STUDIES                                                                                                                                                                                                                                                            |   |   |   | 9                 |
| Mining, power plants, cement plants, highways, petroleum refining industry, storage & handling of hazardous chemicals, common hazardous waste facilities, CETPs, CMSWMF, building and construction projects                                                                                                                                                     |                                                                                                                                                                                                                                                                         |   |   |   |                   |
| REFERENCES:                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                         |   |   |   | Total: 45 periods |
| 1.                                                                                                                                                                                                                                                                                                                                                              | EIA Notification 2006 including recent amendments, by Ministry of Environment, Forest and Climate Change, Government of India                                                                                                                                           |   |   |   |                   |
| 2.                                                                                                                                                                                                                                                                                                                                                              | Sectoral Guidelines under EIA Notification by Ministry of Environment, Forest and Climate Change, Government of India                                                                                                                                                   |   |   |   |                   |
| 3.                                                                                                                                                                                                                                                                                                                                                              | Canter, L.W., Environmental Impact Assessment, McGraw Hill, New York, 1996                                                                                                                                                                                              |   |   |   |                   |
| 4.                                                                                                                                                                                                                                                                                                                                                              | Lawrence, D.P., Environmental Impact Assessment - Practical solutions to recurrent problems, Wiley-Interscience, New Jersey, 2003                                                                                                                                       |   |   |   |                   |

  
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|-----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|-----|------|------|------|
| 5.                                                                                            | Lee N. and George C. 2000, Environmental Assessment in Developing and Transitional Countries, Chichester: Willey                                    |                                      |     |      |      |      |
| 6.                                                                                            | World Bank –Source book on EIA .1999                                                                                                                |                                      |     |      |      |      |
| 7.                                                                                            | Sam Mannan, Lees' Loss Prevention in the Process Industries, Hazard Identification Assessment and Control, 4th Edition, Butterworth Heineman, 2012. |                                      |     |      |      |      |
| <b>COURSE OUTCOMES:</b><br>On completion of the course, the student is expected to be able to |                                                                                                                                                     | <b>BT Mapped<br/>(Highest Level)</b> |     |      |      |      |
| CO1:                                                                                          | Understand need for environmental clearance, its legal procedure, need of EIA, its types, stakeholders and their roles                              | K2                                   |     |      |      |      |
| CO2:                                                                                          | Understand various impact identification methodologies, prediction techniques and model of impacts on various environments                          | K2                                   |     |      |      |      |
| CO3:                                                                                          | Understand relationship between social impacts and change in community due to development activities and rehabilitation methods                     | K2                                   |     |      |      |      |
| CO4:                                                                                          | Document the EIA findings and prepare environmental management and monitoring plan                                                                  | K2                                   |     |      |      |      |
| CO5:                                                                                          | Identify, predict and assess impacts of similar projects based on case studies                                                                      | K2                                   |     |      |      |      |
| <b>Mapping of COs with POs and PSOs</b>                                                       |                                                                                                                                                     |                                      |     |      |      |      |
| COs/POs                                                                                       | PO1                                                                                                                                                 | PO2                                  | PO3 | PSO1 | PSO2 | PSO3 |
| CO1                                                                                           | 1                                                                                                                                                   | 1                                    | 2   | 2    | 3    | 1    |
| CO2                                                                                           | 1                                                                                                                                                   | 1                                    | 3   | 2    | 3    | 1    |
| CO3                                                                                           | 1                                                                                                                                                   | 1                                    | 2   | 3    | 1    | 1    |
| CO4                                                                                           | 2                                                                                                                                                   | 3                                    | 2   | 3    | 2    | 2    |
| CO5                                                                                           | 3                                                                                                                                                   | 2                                    | 3   | 2    | 2    | 1    |
| Avg.                                                                                          | 2                                                                                                                                                   | 2                                    | 2   | 2    | 2    | 2    |
| 1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy                             |                                                                                                                                                     |                                      |     |      |      |      |

  
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| PEVE2405                                                                                                                                                                                                                                                                                                                                                         | SEPTAGE AND ONSITE WASTEWATER TREATMENT TECHNOLOGIES                                                                                                                                                                                                                                                                                                                    |          |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                         | Category | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                         | PEC      | 3 | 0 | 0 | 3      |
| Course objectives                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                         |          |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                  | <ul style="list-style-type: none"><li>To understand on the principles and process designs aspects of onsite sanitation and decentralized wastewater management systems.</li><li>To gain competency in the process employed in sludge and septate management systems and the components comprising such systems, leading to the selection of specific process.</li></ul> |          |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                                                                                                                         | URBANIZATION AND SANITATION                                                                                                                                                                                                                                                                                                                                             |          |   |   |   | 9      |
| Sanitation Infrastructure in Urban India - Emerging Recognition of Faecal Sludge and Septage Management - Sanitation Service Chain -Faecal Sludge and Septage -Need for Faecal Sludge and Septage Management - Septage Management and Sewerage Systems -Components of Sanitation Value Chain- Approach to Septage Management in Cities                           |                                                                                                                                                                                                                                                                                                                                                                         |          |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                                                                                                                        | DESLUDGING AND CONVEYANCE OF SEPTAGE                                                                                                                                                                                                                                                                                                                                    |          |   |   |   | 9      |
| Planning for Emptying Services - Current Status of Emptying Services -Need for Periodic Cleaning of Septic Tanks - Prohibition of Employment as Manual Scavengers and their Rehabilitation Act- Technologies for Desludging - Parameters for Assessing Conveyance Options - Demand Based Desludging - Schedule Based Desludging - Private Sector Participation . |                                                                                                                                                                                                                                                                                                                                                                         |          |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                                                                                                                       | SEWAGE TREATMENT                                                                                                                                                                                                                                                                                                                                                        |          |   |   |   | 9      |
| Unit Operations and Processes – Selection of treatment processes — Onsite sanitation – Septic tank- Grey water harvesting- Decentralized sewage treatment – Design of septic tank with depression pit – DEWATS. Intermittent sand filters – Anaerobic filters – Waste stabilization ponds – Design and operation.                                                |                                                                                                                                                                                                                                                                                                                                                                         |          |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                                        | SLUDGE STABILIZATION                                                                                                                                                                                                                                                                                                                                                    |          |   |   |   | 9      |
| Objectives-Aerobic and Anaerobic Sludge digestion processes – Types of anaerobic digesters – design of Low rate and High rate digesters – Two stage digester-Aerobic digestion- Pure oxygen and thermophilic aerobic digestion - Chemical and Thermal stabilization process                                                                                      |                                                                                                                                                                                                                                                                                                                                                                         |          |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                                                                                                                                         | REUSE AND LAND APPLICATION OF SEWAGE SLUDGE                                                                                                                                                                                                                                                                                                                             |          |   |   |   | 9      |
| Introduction- beneficial use-requirements and associated risks-handling and management-storage - operation aspects of transport and application of biosolids application land- Lagooning- Landfilling-land farming- Composting-windrow composting -Vermicomposting -Laws and regulations on sludge management                                                    |                                                                                                                                                                                                                                                                                                                                                                         |          |   |   |   |        |
| Total: 45+30= 75 Periods                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                         |          |   |   |   |        |
| REFERENCES:                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                         |          |   |   |   |        |
| 1.                                                                                                                                                                                                                                                                                                                                                               | Manual for “Sewerage and Sewage Treatment Systems” CII/IEO, Ministry of Urban Development, Government of India, New Delhi, 2013.                                                                                                                                                                                                                                        |          |   |   |   |        |
| 2.                                                                                                                                                                                                                                                                                                                                                               | Metcalf & Eddy, INC, Wastewater Engineering – Treatment and Reuse, Fourth Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2017.                                                                                                                                                                                                                        |          |   |   |   |        |

  
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| 3. | Septage management in urban India, National Urban Sanitation policy, Ministry of Urban Development Government of India, 2013.                                    |
| 4. | National Policy on Faecal Sludge and Septage Management (FSSM) Ministry of Urban Development Government of India, 2017                                           |
| 5. | A.F. Ismail, Takeshi Matsuura, Membrane Technology for Water and Wastewater Treatment, Energy and Environment, CRC Press, 2016                                   |
| 6. | Michael D. Nelson, Chair, Operation of municipal wastewater treatment plants, Water environment federation, vol.2 liquid process.                                |
| 7. | Michael D. Nelson, Chair, Operation of municipal wastewater treatment plants, Water environment federation, vol.1 Management and support systems, sixth edition. |
| 8. | Arceivala S.J., and Asolekar S.R. "Wastewater Treatment for Pollution Control and reuse "McGraw Hill , third Edition, New Delhi, 2007.                           |

| COURSE OUTCOMES:<br>Upon Completion of the course, the students will be able to |                                                                                       | BT Mapped<br>(Highest Level) |     |      |      |      |
|---------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|------------------------------|-----|------|------|------|
| CO1:                                                                            | Understand the sanitation value chain with challenges and need for addressing septage | K2                           |     |      |      |      |
| CO2:                                                                            | Know about desludging and conveyance of septage                                       | K2                           |     |      |      |      |
| CO3:                                                                            | Plan and implement decentralized sewage treatment scheme                              | K2                           |     |      |      |      |
| CO4:                                                                            | Understand technology options for sludge stabilization                                | K2                           |     |      |      |      |
| CO5:                                                                            | Know about the requirements and associated risk while reusing sewage sludge           | K2                           |     |      |      |      |
| Mapping of COs with POs and PSOs                                                |                                                                                       |                              |     |      |      |      |
| COs/POs                                                                         | PO1                                                                                   | PO2                          | PO3 | PSO1 | PSO2 | PSO3 |
| CO1                                                                             | 2                                                                                     | 1                            | 2   | 1    | 3    | 1    |
| CO2                                                                             | 2                                                                                     | 1                            | 3   | 1    | 2    | 1    |
| CO3                                                                             | 2                                                                                     | 2                            | 3   | 1    | 2    | 3    |
| CO4                                                                             | 2                                                                                     | 1                            | 3   | 2    | 2    | 2    |
| CO5                                                                             | 2                                                                                     | 1                            | 2   | 2    | 3    | 2    |
| Avg.                                                                            | 2                                                                                     | 1                            | 3   | 1    | 2    | 2    |
| 1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom's Taxonomy                |                                                                                       |                              |     |      |      |      |

  
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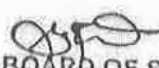
| PEVE2406                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                              | SUSTAINABILITY ENGINEERING                                                                                                                                                                                                                                                                                        |   |   |   |        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|--------|
|                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                              | Category                                                                                                                                                                                                                                                                                                          | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                              | PEC                                                                                                                                                                                                                                                                                                               | 3 | 0 | 0 | 3      |
| Course objectives                                                                                                                                                                                                                                                                                                |                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                   |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                              | <ul style="list-style-type: none"><li>• To learn about the principles, indicators and general concept of sustainability.</li><li>• To apprehend the local, regional and global impacts of unsustainable designs, products and processes.</li><li>• To apply the sustainability concepts in engineering.</li></ul> |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                                                                         | SUSTAINABILITY                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                   |   |   |   | 9      |
| Introduction to sustainability concepts, the magnitude of the pressures on resources and ecosystems. Roles of engineers in developing sustainable society, Energy, Materials use, Environmental emissions –ozone depletion, global warming, air quality, water quality, wastes in the India – water, air, solid. |                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                   |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                                                                        | RISK AND LIFE CYCLE BASED FRAME WORKS FOR SUSTAINABILITY                                                                                                                     |                                                                                                                                                                                                                                                                                                                   |   |   |   | 9      |
| Environmental Risk – Risk assessment, Risk based environmental law, Life cycle – Life cycle assessment, Life cycle based environmental law, Life cycle assessment tools, pollution prevention concepts.                                                                                                          |                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                   |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                                                                       | SUSTAINABLE MATERIALS                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                   |   |   |   | 9      |
| Environmental and natural resource use footprints – material extraction and production, material flows in engineered systems, Environmental releases- chemical and physical properties, estimate environmental partitioning, persistence and measures of exposure.                                               |                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                   |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                                                                        | DESIGN FOR SUSTAINABILITY                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                   |   |   |   | 9      |
| Sustainable engineering design principles, economic performance indicators, environmental performance indicators, social performance indicators, environmental cost analysis                                                                                                                                     |                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                   |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                                                                                         | CASE STUDIES                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                   |   |   |   | 9      |
| Sustainable built environments, Biofuels for transportation, electric vehicles, bioplastics.                                                                                                                                                                                                                     |                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                   |   |   |   |        |
| Total: 45 periods                                                                                                                                                                                                                                                                                                |                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                   |   |   |   |        |
| REFERENCES                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                   |   |   |   |        |
| 1.                                                                                                                                                                                                                                                                                                               | Sustainable Engineering concepts, design and case studies, David T. Allen and David R.Shonnard, Prentice hall.                                                               |                                                                                                                                                                                                                                                                                                                   |   |   |   |        |
| 2.                                                                                                                                                                                                                                                                                                               | Engineering applications in sustainable design and development , Bradley Striebig, Adebayao A.Ogundipe and Maria Papadakis, Cengage Learning, 001 edition (January 1, 2015). |                                                                                                                                                                                                                                                                                                                   |   |   |   |        |

  
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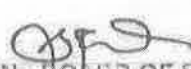
| COURSE OUTCOMES: |                                                                                                                                     | BT Mapped<br>(Highest Level) |
|------------------|-------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
| CO1:             | Students would be able to quantify sustainability, and resource availability.                                                       | K2                           |
| CO2:             | Rationalize the sustainability based on scientific merits                                                                           | K2                           |
| CO3:             | Understand and apply sustainability concepts in designs, product developments and processes across various engineering disciplines. | K2                           |
| CO4:             | To make a decision in applying green engineering concepts.                                                                          | K2                           |
| CO5:             | Lifelong advocate of sustainability in society.                                                                                     | K2                           |

| Mapping of COs with POs and PSOs |     |     |     |      |      |      |
|----------------------------------|-----|-----|-----|------|------|------|
| COs/POs                          | PO1 | PO2 | PO3 | PSO1 | PSO2 | PSO3 |
| CO1                              | 1   | 2   | 3   | 1    | 3    | 2    |
| CO2                              | 1   | 2   | 2   | 2    | 2    | 1    |
| CO3                              | 3   | 1   | 3   | 2    | 3    | 1    |
| CO4                              | 2   | 1   | 2   | 2    | 3    | 2    |
| CO5                              | 1   | 1   | 2   | 2    | 3    | 1    |
| Avg.                             | 2   | 1   | 3   | 2    | 3    | 2    |

1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom's Taxonomy

  
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| PEVE2407                                                                                                                                                                                                                                                                                                                                      | PROJECT FORMULATION AND IMPLEMENTATION                                                                                                                                                                                                                                                                                                                                                                    |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                               | Category                                                                                                                                                                                                                                                                                                                                                                                                  | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                                                               | PEC                                                                                                                                                                                                                                                                                                                                                                                                       | 3 | 0 | 0 | 3      |
| Course objectives                                                                                                                                                                                                                                                                                                                             | <ul style="list-style-type: none"> <li>To examine the techniques and procedures relevant for project planning and implementation in developing countries, especially infrastructure projects pertaining to environmental sector</li> <li>To enable the students to understand about project identification, feasibility analysis, design, financing, implementation, monitoring and evaluation</li> </ul> |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                                                                                                      | INTRODUCTION TO PROJECT FORMULATION                                                                                                                                                                                                                                                                                                                                                                       |   |   |   | 9      |
| Overview of the project cycle – planning process and project planning – search for project ideas – strategies in capital allocation – key elements in project formulation – methods and tools for project formulation – project identification and selection – preparation of feasibility reports as per government policies (AMRUT / JnNURM) |                                                                                                                                                                                                                                                                                                                                                                                                           |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                                                                                                     | PROJECT ANALYSIS                                                                                                                                                                                                                                                                                                                                                                                          |   |   |   | 8      |
| Capital cost estimation – market demand analysis – technical analysis – environmental analysis – financial and economic analysis – cash flow generation                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                           |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                                                                                                    | PROJECT APPRAISAL                                                                                                                                                                                                                                                                                                                                                                                         |   |   |   | 10     |
| Time and value of money – investment criteria – internal rate of return – net present value, cost benefit analysis, and social cost benefit analysis – project risk analysis – appraisal of marketing strategy – pricing and credit worthiness and management capabilities                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                           |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                     | PROJECT FINANCING AND IMPLEMENTATION                                                                                                                                                                                                                                                                                                                                                                      |   |   |   | 10     |
| Funding options for urban and rural development projects – tender procedure – transparency in government tender rules – organizational aspects in project management – network techniques for project management – resource management – risk management                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                           |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                                                                                                                      | PROJECT MONITORING AND EVALUATION                                                                                                                                                                                                                                                                                                                                                                         |   |   |   | 8      |
| Need and techniques for monitoring – service Level benchmark performance and process monitoring – monitoring Schedules – Penalty and Bonus points                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                           |   |   |   |        |
| REFERENCES:                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                           |   |   |   |        |
| 1                                                                                                                                                                                                                                                                                                                                             | Clifford I Gray, Erik W Larson, "Project Management-The Managerial Process" Tata McGraw-Hill Publishing Co Ltd                                                                                                                                                                                                                                                                                            |   |   |   |        |
| 2                                                                                                                                                                                                                                                                                                                                             | Jack Meredith, Samuel J Mantel Jr, "Project Management- A Managerial Approach" John Wiley and Sons                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| 3                                                                                                                                                                                                                                                                                                                                             | John M Nicholas "Project Management for Business and Technology" Prentice Hall Of India Pvt Ltd                                                                                                                                                                                                                                                                                                           |   |   |   |        |
| 4                                                                                                                                                                                                                                                                                                                                             | James P Lewis "Project Planning, Scheduling And Control" Tata McGraw-Hill                                                                                                                                                                                                                                                                                                                                 |   |   |   |        |
| 5                                                                                                                                                                                                                                                                                                                                             | Detailed Project Report, Preparation Toolkit (Sub-mission for Urban Infrastructure and Governance),                                                                                                                                                                                                                                                                                                       |   |   |   |        |
| 6                                                                                                                                                                                                                                                                                                                                             | www.india.gov.in national portal for India                                                                                                                                                                                                                                                                                                                                                                |   |   |   |        |

  
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| <b>COURSE OUTCOMES:</b><br>On completion of the course, the student is expected to be able to |                                                                                                                                                                    | <b>BT Mapped<br/>(Highest Level)</b> |     |      |      |      |
|-----------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|-----|------|------|------|
| CO1:                                                                                          | Understand the project cycle, key elements in project formulation, methods and tools for project formulation                                                       | K2                                   |     |      |      |      |
| CO2:                                                                                          | Understand capital cost estimation, market and demand analysis, technical, environmental, financial and economic analysis                                          | K2                                   |     |      |      |      |
| CO3:                                                                                          | Understand time and value of money, investment criteria, internal rate of return, cost benefit analysis, project risk analysis and appraisal of marketing strategy | K2                                   |     |      |      |      |
| CO4:                                                                                          | Have knowledge on funding options for urban and rural development projects, tender procedure, transparency, resource management & risk management                  | K2                                   |     |      |      |      |
| CO5:                                                                                          | Understand need and techniques for monitoring project performance                                                                                                  | K2                                   |     |      |      |      |
| <b>Mapping of COs with POs and PSOs</b>                                                       |                                                                                                                                                                    |                                      |     |      |      |      |
| COs/POs                                                                                       | PO1                                                                                                                                                                | PO2                                  | PO3 | PSO1 | PSO2 | PSO3 |
| CO1                                                                                           | 3                                                                                                                                                                  | -                                    | 2   | 3    | 2    | 2    |
| CO2                                                                                           | 3                                                                                                                                                                  | 1                                    | 3   | 3    | 1    | 1    |
| CO3                                                                                           | 1                                                                                                                                                                  | 1                                    | 3   | 3    | 1    | 1    |
| CO4                                                                                           | 1                                                                                                                                                                  | 3                                    | 3   | 3    | 1    | 1    |
| CO5                                                                                           | 2                                                                                                                                                                  | -                                    | 3   | 3    | 2    | 1    |
| Avg.                                                                                          | 2                                                                                                                                                                  | 1                                    | 3   | 3    | 2    | 1    |
| 1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy                             |                                                                                                                                                                    |                                      |     |      |      |      |

  
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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |   |   |   |        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|--------|
| PEVE2408                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | ADVANCED OXIDATION PROCESS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Category                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | PEC                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 3 | 0 | 0 | 3      |
| Course objectives                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <ul style="list-style-type: none"><li>To identify the most critical issues and challenges that limit the use of conventional treatment processes in planning, design and operation of modern water and wastewater treatment facilities</li><li>To understand the fundamentals of advanced oxidation processes (AOPs), photochemistry, ozone chemistry, and its application to AOPs for the detoxification of contaminated water</li><li>To develop in-depth knowledge that can be used to devise and design effective AOP treatment systems to meet not only current but also anticipated regulatory requirements, and to enhance independent learning and critical thinking skills.</li></ul> |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | INTRODUCTION TO AOPs                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |   |   |   | 8      |
| Introduction to AOPs for water and wastewater treatment – mechanism – photooxidation reactions photocatalytic reactions, photo-initiated oxidation – UV- H <sub>2</sub> O <sub>2</sub> / ozonation, fenton / photofenton – photocatalysis – light source choice – used in AOPs and their spectral distributions.                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | HOMOGENOUS AOPs                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |   |   |   | 8      |
| Ozone, electro-chemical oxidation, ultrasonication, UV – photolysis, hydrogen peroxide and ultraviolet radiation (H <sub>2</sub> O <sub>2</sub> /UV), Fenton and Photo Fenton's oxidation, chemical and non-chemical AOPs, advantages and disadvantages of homogeneous processes.                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | HETEROGENEOUS PROCESS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |   |   |   | 10     |
| Introduction to nano & heterogeneous photocatalysis effect of system composition and process. Identification of degradation products, photoreactors (liquid phase/ gas phase) – solar/ artificial light photo reactors – operation of pilot plants – comparing reactor efficiencies – system design – solar collectors – technology issues – slurry, supported catalyst – reuse – novel photocatalysis, synthesis methods – bulk, chemical approaches, physical approaches, nanoporous materials – physic chemical methods for characterization of nanomaterials |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | AOP ENHANCEMENT TECHNIQUES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |   |   |   | 9      |
| Non-thermal plasma-electron hydraulic cavitation and sonolysis- super water oxidation – $\gamma$ rays-electron beams, Quantum yield improvement by additional oxidants – hydrogen peroxide persulphate- catalyst modification, case studies and applications semiconductor photolysis, process fundamentals, applications and commercial process.                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | INDUSTRIAL APPLICATIONS AND ECONOMIC ASSESSMENT OF AOPs                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   | 10     |
| Application of AOPs for textile, petroleum, pharmaceutical and petrochemical industries - ground water decontamination – drinking water treatment – pilot & land fill photochemical - cost calculation- economic analysis.                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |   |   |   |        |

  
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| REFERENCES: |                                                                                                                                                                                                     |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.          | Cao G., "Nanostructures & Nanomaterials: Synthesis, Properties & Applications". Imperial College Press, 2004.                                                                                       |
| 2.          | Rose R. M., Shepard L. A. and Wulff J., "The Structure and Properties of Materials". Wiley Eastern Ltd.                                                                                             |
| 3.          | Simon Parsons, "Advanced oxidation processes for water and wastewater treatment". IWA Publishing, 2004                                                                                              |
| 4.          | Thomas Oppenländer, "Photochemical Purification of Water and Air: Advanced Oxidation Processes (AOPs): Principles, Reaction Mechanisms, Reactor Concepts". Wiley-VCH Publishing. Published by, 2003 |
| 5.          | Marta, I. Litter, Roberts J. Candal, J. Martin Meichtry, "Advanced Oxidation Technologies: Sustainable Solution for Environmental Treatment", CRC Press, 2014.                                      |
| 6.          | R.M. Rose, L.A. Shepard and J. Wulff, "The Structure and Properties of Materials", Wiley Eastern Ltd. 1996.                                                                                         |

| COURSE OUTCOMES:                                                   |                                                                                                                                                                     | BT Mapped<br>(Highest Level) |     |      |      |      |
|--------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|-----|------|------|------|
| On Completion of the course, the student is expected to be able to |                                                                                                                                                                     |                              |     |      |      |      |
| CO1:                                                               | Comprehend the basic principles of advanced water treatment processes, capabilities / constraints of their application in water and wastewater treatment            | K2                           |     |      |      |      |
| CO2:                                                               | Apply technical knowledge and skills on the design and operation of AOPs for the water and wastewater treatment                                                     | K2                           |     |      |      |      |
| CO3:                                                               | Design suitable pre-treatment and post treatment schemes; and cleaning protocols for AOPs                                                                           | K2                           |     |      |      |      |
| CO4:                                                               | Conduct economic assessment on AOTs for water and wastewater treatment                                                                                              | K2                           |     |      |      |      |
| CO5:                                                               | Select appropriate AOPs to solve emerging environmental wastewater issues in the society, that are technically sound, economically feasible and socially acceptable | K2                           |     |      |      |      |
| Mapping of COs with POs and PSOs                                   |                                                                                                                                                                     |                              |     |      |      |      |
| COs/POs                                                            | PO1                                                                                                                                                                 | PO2                          | PO3 | PSO1 | PSO2 | PSO3 |
| CO1                                                                | 1                                                                                                                                                                   | 1                            | 3   | 3    | 1    | 1    |
| CO2                                                                | 3                                                                                                                                                                   | 1                            | 3   | 2    | 1    | 1    |
| CO3                                                                | 2                                                                                                                                                                   | 3                            | 3   | 3    | 1    | 1    |
| CO4                                                                | 1                                                                                                                                                                   | 3                            | 3   | 1    | 1    | 1    |
| CO5                                                                | 3                                                                                                                                                                   | 1                            | 3   | 3    | 3    | 3    |
| Avg.                                                               | 2                                                                                                                                                                   | 2                            | 3   | 2    | 1    | 2    |
| 1 – Slight, 2 – Moderate, 3 – Substantial, B1 – Bloom's Taxonomy   |                                                                                                                                                                     |                              |     |      |      |      |

  
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|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|--------|
| PEVE2409                                                                                                                                                                                                                                                      | COMPUTING TECHNIQUES IN ENVIRONMENTAL ENGINEERING                                                                                                                                                                                                                                |   |   |   |        |
|                                                                                                                                                                                                                                                               | Category                                                                                                                                                                                                                                                                         | L | T | P | Credit |
|                                                                                                                                                                                                                                                               | PEC                                                                                                                                                                                                                                                                              | 3 | 0 | 0 | 3      |
| Course objectives                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                  |   |   |   |        |
|                                                                                                                                                                                                                                                               | <ul style="list-style-type: none"><li>To educate the students to know about the computing techniques used in environmental engineering, and explain the artificial intelligence like ANN, Fuzzy logic and genetic algorithm applications in environmental engineering.</li></ul> |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                      | SOFT COMPUTING PRINCIPLES                                                                                                                                                                                                                                                        |   |   |   | 9      |
| Introduction to computing techniques – algorithms and flowcharts, numerical methods - solution to ordinary and partial differential equation using finite difference, finite element and finite volume methods, numerical integration and differentiation.    |                                                                                                                                                                                                                                                                                  |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                     | ARTIFICIAL INTELLIGENCE                                                                                                                                                                                                                                                          |   |   |   | 9      |
| Knowledge based expert system concepts - principle of Artificial Neural Network (ANN) – perceptron learning rule, neural network structure – neural network operations – ANN Algorithm - Application of ANN Model to environmental field – genetic algorithms |                                                                                                                                                                                                                                                                                  |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                    | FUZZY LOGIC                                                                                                                                                                                                                                                                      |   |   |   | 9      |
| Fuzzy logic principles - fuzzy logic and the theory of uncertainty - fuzzy set theory- fuzzy membership function, fuzzy relations, fuzzy rule, and applications of the fuzzy set theory to inference and control, clustering, and image processing.           |                                                                                                                                                                                                                                                                                  |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                     | DIGITAL DATA MANAGEMENT                                                                                                                                                                                                                                                          |   |   |   | 9      |
| Data base structure - data acquisition - data warehouse - DBMS - RDBMS - data analysis - network data sharing - Statistical Analysis (SYSTAT) - regression - factor analysis - histogram - scatter diagram - goodness of fit – big data analysis.             |                                                                                                                                                                                                                                                                                  |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                                      | ENVIRONMENTAL MODELING SOFTWARE                                                                                                                                                                                                                                                  |   |   |   | 9      |
| Introduction to MATLAB Software – MATLAB applications in environmental – pollutants transport, decay and degradation modeling using MIKE 21 – MODFLOW - case studies.                                                                                         |                                                                                                                                                                                                                                                                                  |   |   |   |        |
| REFERENCES:                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                  |   |   |   |        |
| 1.                                                                                                                                                                                                                                                            | Aliev R. A. and Aliev Rashad, "Soft Computing and its Applications", World Scientific Publications Co. Pte. Ltd. Singapore, 2017.                                                                                                                                                |   |   |   |        |
| 2.                                                                                                                                                                                                                                                            | Chepra S. C. and Canele R. P., "Numerical Methods for Engineers", McGraw-Hill, a business unit of The McGraw- Hill Companies, Inc., 1221 Avenue of the Americas, New York, NY 10020. 6th Edition 2018.                                                                           |   |   |   |        |
| 3.                                                                                                                                                                                                                                                            | Data-Driven Modeling: Using MATLAB in Water Resources and Environmental Engineering, Springer; 2014 edition.                                                                                                                                                                     |   |   |   |        |
| 4.                                                                                                                                                                                                                                                            | Mathews J. H. and Fink K.D. "Numerical methods using MATLAB", Pearson Education 2018.                                                                                                                                                                                            |   |   |   |        |

  
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| COURSE OUTCOMES:<br>On completion of the course, the students are able to |                                                                                      | BT Mapped<br>(Highest Level) |
|---------------------------------------------------------------------------|--------------------------------------------------------------------------------------|------------------------------|
| CO1:                                                                      | Understand the various computing techniques available for environmental engineering. | K2                           |
| CO2:                                                                      | Apply the principles of ANN and GA for solving environmental problems                | K2                           |
| CO3:                                                                      | Apply the principles of Fuzzy logic and for solving environmental problems.          | K2                           |
| CO4:                                                                      | Work in the statistical analysis software SYSTAT.                                    | K2                           |
| CO5:                                                                      | Employ modern advanced computing tool MATLAB software in environmental studies       | K2                           |

| Mapping of COs with POs and PSOs |     |     |     |      |      |      |
|----------------------------------|-----|-----|-----|------|------|------|
| COs/POs                          | PO1 | PO2 | PO3 | PSO1 | PSO2 | PSO3 |
| CO1                              | 2   | 2   | 3   | 3    | 2    | 2    |
| CO2                              | 2   | 2   | 3   | 3    | 2    | 1    |
| CO3                              | 1   | 1   | 3   | 3    | 2    | 1    |
| CO4                              | 1   | 3   | 3   | 3    | 2    | 2    |
| CO5                              | 1   | 2   | 3   | 3    | 1    | 3    |
| Avg.                             | 1   | 2   | 3   | 3    | 2    | 2    |

1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom's Taxonomy

  
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|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|--------|
| PEVE2410                                                                                                                                                                                                                                         |                                                                                                                                                                                 | GEO-ENVIRONMENTAL ENGINEERING                                                                                                                                                                                                                                                                                                                 |   |   |   |        |
|                                                                                                                                                                                                                                                  |                                                                                                                                                                                 | Category                                                                                                                                                                                                                                                                                                                                      | L | T | P | Credit |
|                                                                                                                                                                                                                                                  |                                                                                                                                                                                 | PEC                                                                                                                                                                                                                                                                                                                                           | 3 | 0 | 0 | 3      |
| Course objectives                                                                                                                                                                                                                                |                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                               |   |   |   |        |
|                                                                                                                                                                                                                                                  |                                                                                                                                                                                 | <ul style="list-style-type: none"><li>• To acquire the knowledge on the Geotechnical engineering problems associated with soil contamination.</li><li>• To safe disposal of waste and remediate the contaminated soils by different techniques</li><li>• To remediate the contaminated ground water thereby protecting environment.</li></ul> |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                         | INTRODUCTION                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                               |   |   |   | 8      |
| Emergence of Geo-Environmental engineering. Types of Geo-Environmental problems, inorganic and organic toxic chemicals, composition of soils, soil properties, inorganic and organic geochemistry.                                               |                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                               |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                        | CONTAMINANT TRANSPORT AND FATE                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                               |   |   |   | 10     |
| Transport processes, chemical mass transfer processes, biological processes, contaminant transport and fate modeling, landfill and surface impoundments, in-situ barriers, ground water contamination                                            |                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                               |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                       | SUBSURFACE CONTAMINATION AND WASTE CONTAINMENT                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                               |   |   |   | 10     |
| Sources and types of contamination, remediation approach, contaminated site characterization, risk assessment and remedial strategy. Vertical and bottom barriers, surface caps, ground water pumping systems, subsurface drains, liner systems. |                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                               |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                        | SOIL REMEDIATION                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                               |   |   |   | 8      |
| Soil vapour extraction, soil washing, stabilization and solidification, electrokinetic remediation, thermal desorption, vitrification, bioremediation, phytoremediation, soil fracturing.                                                        |                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                               |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                         | GROUND WATER REMEDIATION                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                               |   |   |   | 9      |
| Pump and treat, In-situ flushing, permeable reactive barriers, in-situ air sparing monitored natural attenuation, bioremediation.                                                                                                                |                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                               |   |   |   |        |
| REFERENCES:                                                                                                                                                                                                                                      |                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                               |   |   |   |        |
| 1.                                                                                                                                                                                                                                               | Sharma H.D. and Reddy K.R., "Geoenvironmental Engineering: Site Remediation, Waste Containment, and Emerging Waste Management Technologies" John Wiley & Sons, Inc., USA, 2004. |                                                                                                                                                                                                                                                                                                                                               |   |   |   |        |
| 2.                                                                                                                                                                                                                                               | Yong, R. N., "Geoenvironmental Engineering, Contaminated Soils, Pollutant Fate, and Mitigation" CRC Press, New York, 2001.                                                      |                                                                                                                                                                                                                                                                                                                                               |   |   |   |        |
| 3.                                                                                                                                                                                                                                               | Reddi L.N. and Inyang, H. I., "Geoenvironmental Engineering, Principles and Applications" Marcel Dekker Inc, New York, 2000.                                                    |                                                                                                                                                                                                                                                                                                                                               |   |   |   |        |

  
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| COURSE OUTCOMES:<br>On completion of the course, the students are able to |                                                                          | BT Mapped<br>(Highest Level) |
|---------------------------------------------------------------------------|--------------------------------------------------------------------------|------------------------------|
| CO1:                                                                      | Assess the contamination in the soil                                     | K2                           |
| CO2:                                                                      | Understand the current practice of waste disposal                        | K2                           |
| CO3:                                                                      | To prepare the suitable disposal system for particular waste.            | K2                           |
| CO4:                                                                      | Stabilize the waste and utilization of solid waste for soil improvement. | K2                           |
| CO5:                                                                      | Select suitable remediation methods based on contamination               | K2                           |

| Mapping of COs with POs and PSOs |     |     |     |      |      |      |
|----------------------------------|-----|-----|-----|------|------|------|
| COs/POs                          | PO1 | PO2 | PO3 | PSO1 | PSO2 | PSO3 |
| CO1                              | 2   | 1   | 3   | 2    | 1    | 1    |
| CO2                              | 2   | 2   | 3   | 3    | 2    | 2    |
| CO3                              | 3   | 1   | 2   | 2    | 1    | 1    |
| CO4                              | 3   | 1   | 3   | 3    | 2    | 1    |
| CO5                              | 2   | 1   | 2   | 3    | 1    | 1    |
| Avg.                             | 2   | 1   | 3   | 3    | 2    | 1    |

1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy

  
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| PEVE2411                                                                                                                                                                                                                                                                                                      | ENVIRONMENTAL MONITORING INSTRUMENTS                                                                                                    |          |   |   |   |        |
|                                                                                                                                                                                                                                                                                                               |                                                                                                                                         | Category | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                               |                                                                                                                                         | PEC      | 3 | 0 | 0 | 3      |
| Course objectives                                                                                                                                                                                                                                                                                             |                                                                                                                                         |          |   |   |   |        |
|                                                                                                                                                                                                                                                                                                               | * To educate the students on various instrumental methods of monitoring the quality of air, water and soil.                             |          |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                                                                      | FUNDAMENTALS                                                                                                                            |          |   |   |   | 9      |
| Wet chemistry methods and their limitations-instrumental methods, selection of method- precision and accuracy, error in measuring signals- quality control & assurance- sample preservation, sample preparation and analyte isolation.                                                                        |                                                                                                                                         |          |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                                                                     | SPECTROSCOPIC METHODS                                                                                                                   |          |   |   |   | 12     |
| Principles, techniques and applications of spectrophotometry, fluorimetry, nephelometry and turbidimetry. Atomic Absorption Spectrometry (Flame, graphite furnace, cold vapour and hydride generation), Atomic Emission Spectrometry (AES), Flame photometry and Inducted Coupled Plasma (ICP) – TOC Analyzer |                                                                                                                                         |          |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                                                                    | CHROMATROGRAPHIC METHODS                                                                                                                |          |   |   |   | 8      |
| Principles, techniques and applications of GC, GC-MS, high performance liquid chromatography (HPLC) and Ion Chromatography (IC)-hyphenated techniques for environmental contaminant (trace organics) analysis, ICP-MS                                                                                         |                                                                                                                                         |          |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                                                                     | ELECTRO AND RADIO ANALYTICAL METHODS                                                                                                    |          |   |   |   | 8      |
| Principles, techniques and applications of conductometry, potentiometry, coulometry, AOX Analyzer, amperometry, polarography, electro-capillary analysis, Neutron Activation Analysis (NAA), X-ray Fluorescence (XRF) and X-ray Diffraction (XRD) methods.                                                    |                                                                                                                                         |          |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                                                                                      | CONTINUOUS MONITORING INSTRUMENTS                                                                                                       |          |   |   |   | 8      |
| Principles, techniques and applications of NDIR analyzer for CO, chemiluminescent analyzer for NOx, fluorescent analyzer for SO2- particulates analysis- auto analyzer for water quality using flow injection analysis, LIMS.                                                                                 |                                                                                                                                         |          |   |   |   |        |
| REFERENCES:                                                                                                                                                                                                                                                                                                   |                                                                                                                                         |          |   |   |   |        |
| 1.                                                                                                                                                                                                                                                                                                            | Willard H. Merritt, L. Dean, D.A. and Settle, F.A. 'Instrumental methods of analysis Edn. Words Worth, New York, 2004.                  |          |   |   |   |        |
| 2.                                                                                                                                                                                                                                                                                                            | Paul R. Loconto Trace Environmental Quantitative Analysis: Principles, Techniques, and Applications, Marcel Dekker: 2nd Edition , 2005. |          |   |   |   |        |
| 3.                                                                                                                                                                                                                                                                                                            | Ewing Instrumental Methods of Chemical Analysis, 5th Edition, McGraw Hill, New York, 1985                                               |          |   |   |   |        |
| 4.                                                                                                                                                                                                                                                                                                            | Reeve, R.N., "Introduction to Environmental Analysis", Analytical Techniques in the Sciences, John Wiley & Sons, Chichester, UK, 2002.  |          |   |   |   |        |
| 5.                                                                                                                                                                                                                                                                                                            | Barcelo, D.(editor), "Environmental analysis. Techniques, Applications and Quality Assurance", Elsevier, The Netherlands, 1996          |          |   |   |   |        |

  
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| COURSE OUTCOMES: |                                                                                  | BT Mapped<br>(Highest Level) |
|------------------|----------------------------------------------------------------------------------|------------------------------|
| CO1:             | Able to select appropriate instrumental method for chemical analysis             | K2                           |
| CO2:             | Understand spectroscopic methods of analysis of pollutants                       | K2                           |
| CO3:             | Select correct method for toxic organics estimation using chromatography methods | K2                           |
| CO4:             | Understand electro and nondestructive methods of analysis                        | K2                           |
| CO5:             | Familiar with online analyzers                                                   | K2                           |

| Mapping of COs with POs and PSOs |     |     |     |      |      |      |
|----------------------------------|-----|-----|-----|------|------|------|
| COs/POs                          | PO1 | PO2 | PO3 | PSO1 | PSO2 | PSO3 |
| CO1                              | 2   | 1   | 3   | 3    | 1    | 1    |
| CO2                              | 2   | 1   | 3   | 2    | 1    | 1    |
| CO3                              | 2   | 1   | 2   | 2    | 1    | 1    |
| CO4                              | 2   | 1   | 3   | 3    | 2    | 1    |
| CO5                              | 3   | 1   | 3   | 3    | 1    | 3    |
| Avg.                             | 2   | 1   | 3   | 3    | 1    | 1    |

1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom's Taxonomy

  
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|                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                          |   |   |   |        |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|--------|
| PEVE2412                                                                                                                                                                                                                                                                                          | WATER QUALITY MODELLING                                                                                                                                                                                                  |   |   |   |        |
|                                                                                                                                                                                                                                                                                                   | Category                                                                                                                                                                                                                 | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                   | PEC                                                                                                                                                                                                                      | 3 | 0 | 0 | 3      |
| Course objectives                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                          |   |   |   |        |
|                                                                                                                                                                                                                                                                                                   | ● To understand the fundamentals of mathematical models and their importance in water quality modelling, and to impart the skills to use water quality modelling software for surface and groundwater quality modelling. |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                                                          | MODELLING INSIGHTS                                                                                                                                                                                                       |   |   |   | 9      |
| Engineers and Mathematical models-Water quality models – historical development - different types of models-- steps in model development - importance of model building.- calibration and verification of models- finite element, finite difference and finite volume methods.                    |                                                                                                                                                                                                                          |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                                                         | POLLUTANT TRANSPORT                                                                                                                                                                                                      |   |   |   | 9      |
| Transport phenomena – advection, diffusion, dispersion- contamination transport in surface and subsurface water - Simple transport models --steady state and time variable solutions- conservation of mass, momentum and energy balance, governing equation for contaminant fate and transport    |                                                                                                                                                                                                                          |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                                                        | SURFACE WATER QUALITY MODELLING                                                                                                                                                                                          |   |   |   | 10     |
| Water quality modeling of streams, lakes and estuaries – water quality– model sensitivity – assessing model performance; Models for dissolved oxygen, pathogens and BOD-Streeter Phelp’s model for point and distributed sources - modified streeter Phelp’s equations. Tropic status assessment. |                                                                                                                                                                                                                          |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                                                         | GROUNDWATER QUALITY MODELLING                                                                                                                                                                                            |   |   |   | 9      |
| Groundwater flow and mass transport of solutes – groundwater quality modelling using numerical methods - degradation of organic compounds in sub surface - prediction of contaminant transport and particle tracking - seawater intrusion – basic concepts and modelling.                         |                                                                                                                                                                                                                          |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                                                                          | WATER QUALITY MODELLING SOFTWARE                                                                                                                                                                                         |   |   |   | 8      |
| Exposure to surface water and groundwater quality modelling software’s – MIKE 21, WASP, QUAL2E and MODFLOW – demonstration - case studies.                                                                                                                                                        |                                                                                                                                                                                                                          |   |   |   |        |
| Total: 45 periods                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                          |   |   |   |        |
| REFERENCES:                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                          |   |   |   |        |
| 1.                                                                                                                                                                                                                                                                                                | Steven C. Chapra, “Surface Water Quality Modelling”, Tata McGraw-Hill Companies, Inc., New Delhi 2018.                                                                                                                   |   |   |   |        |
| 2.                                                                                                                                                                                                                                                                                                | “Water Quality Modelling for Rivers and Streams” Authors: Benedini, Marcello, Tsakiris, George, Springer Netherlands 2017.                                                                                               |   |   |   |        |
| 3.                                                                                                                                                                                                                                                                                                | “Hydrodynamics and Water Quality: Modelling Rivers, Lakes, and Estuaries”, Zhen-Gang Ji, John Wiley & Sons, 2018.                                                                                                        |   |   |   |        |
| 4.                                                                                                                                                                                                                                                                                                | “Modelling Groundwater Flow and Contaminant Transport By Jacob Bear, A. H.-D. Cheng, Springer Science & Business Media, 2010.                                                                                            |   |   |   |        |
| 5.                                                                                                                                                                                                                                                                                                | “Mathematical Modelling of Groundwater Pollution” Ne-Zheng Sun, Alexander Sun, Springer New York, 2012                                                                                                                   |   |   |   |        |

|                                                           |                                                                          |                                  |
|-----------------------------------------------------------|--------------------------------------------------------------------------|----------------------------------|
| <b>COURSE OUTCOMES:</b>                                   |                                                                          | <b>BT Mapped (Highest Level)</b> |
| On completion of the course, the students will be able to |                                                                          |                                  |
| CO1:                                                      | Know about the principles of water quality modelling.                    | Understand                       |
| CO2:                                                      | Understand the pollutant transport phenomena in surface and groundwater. | Understand                       |

  
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|-------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|------|----------|----------|------|------|------|
| CO3:                                                              | Apply the knowledge of surface water quality-modelling to predict the water quality of rivers, lakes and estuary. |     |     |     |     |     |     |     |     |      | Apply    |          |      |      |      |
| CO4:                                                              | Predict the groundwater contamination transport.                                                                  |     |     |     |     |     |     |     |     |      | Analyze  |          |      |      |      |
| CO5:                                                              | Predict water quality of surface and sub surface water using numerical solution.                                  |     |     |     |     |     |     |     |     |      | Analyze  |          |      |      |      |
| Mapping of COs with POs and PSOs                                  |                                                                                                                   |     |     |     |     |     |     |     |     |      |          |          |      |      |      |
| COs/POs                                                           | PO1                                                                                                               | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO1<br>1 | PO1<br>2 | PSO1 | PSO2 | PSO3 |
| CO1                                                               | 2                                                                                                                 | 2   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | -        | 3    | 1    | 1    |
| CO2                                                               | 2                                                                                                                 | 2   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | -        | 3    | 1    | 1    |
| CO3                                                               | 3                                                                                                                 | 1   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | -        | 3    | 1    | 1    |
| CO4                                                               | 2                                                                                                                 | 1   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | -        | 2    | 1    | 1    |
| CO5                                                               | 3                                                                                                                 | 3   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | -        | 3    | 1    | 1    |
| Avg.                                                              | 2                                                                                                                 | 2   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | -        | 3    | 1    | 1    |
| 1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom’s Taxonomy |                                                                                                                   |     |     |     |     |     |     |     |     |      |          |          |      |      |      |

  
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|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|---|---|---|--------|--|
| PEVE2413                                                                                                                                                                                                                                                                                                                                                                        | MARINE POLLUTION AND CONTROL                                                                                                            |   |   |   |        |  |
|                                                                                                                                                                                                                                                                                                                                                                                 | Category                                                                                                                                | L | T | P | Credit |  |
|                                                                                                                                                                                                                                                                                                                                                                                 | PEC                                                                                                                                     | 3 | 0 | 0 | 3      |  |
| Course objectives                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                         |   |   |   |        |  |
|                                                                                                                                                                                                                                                                                                                                                                                 | ● To impart the knowledge about marine and coastal environment, oceanography, and sources, effects and monitoring of marine pollutants. |   |   |   |        |  |
| UNIT – I                                                                                                                                                                                                                                                                                                                                                                        | MARINE AND COASTAL ENVIRONMENT                                                                                                          |   |   |   | 9      |  |
| Seas and oceans, continental area, coastal zone, properties of sea water, principles of marine geology, coastal features – beaches, estuaries, lagoons, salt marshes, mangroves and sand dunes– the oceans and climate, coastal zone regulation in india- national and international treaties.                                                                                  |                                                                                                                                         |   |   |   |        |  |
| UNIT – II                                                                                                                                                                                                                                                                                                                                                                       | OCEAN HYDRODYNAMICS                                                                                                                     |   |   |   | 9      |  |
| Wave theory, waves in shallow waters – refraction, diffraction and shoaling, approximations for deep and shallow water conditions – tidal classification - general circulation of ocean waters – ocean currents - coastal sediment transport - onshore offshore sediment transport - beach formation and coastal processes - Tsunamis, storm surge, El Nino effect.             |                                                                                                                                         |   |   |   |        |  |
| UNIT – III                                                                                                                                                                                                                                                                                                                                                                      | MARINE POLLUTION                                                                                                                        |   |   |   | 9      |  |
| Sources of marine pollution – point and non-point sources, pollution caused by effluent discharge, oil exploration, dredging, offshore mining, port and harbour activities, power plants, agriculture runoff, plastic waste, marine debris and marine litter - effects of marine pollution on marine water quality and coastal ecosystems.                                      |                                                                                                                                         |   |   |   |        |  |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                                                       | MARINE POLLUTION MONITORING                                                                                                             |   |   |   | 9      |  |
| Basic measurements - sounding boat, echo sounders – current meters - tide gauge - use of GPS – measurement of coastal water characteristics – sea bed sampling – modelling of pollutant transport and dispersion - oil spill models - ocean monitoring satellites – applications of remote sensing and GIS in monitoring marine pollution – online marine pollution monitoring, |                                                                                                                                         |   |   |   |        |  |
| UNIT – V                                                                                                                                                                                                                                                                                                                                                                        | MARINE POLLUTION CONTROL MEASURES                                                                                                       |   |   |   | 9      |  |
| Marine discharges and effluent standards, pollution control strategies – marine outfall designselection of optimal marine outfall locations - Total Maximum Daily Load (TMDL) applications – protocols in marine pollution control– Integrated Coastal Zone Management (ICZM) and sustainable development.                                                                      |                                                                                                                                         |   |   |   |        |  |
| Total: 45 periods                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                         |   |   |   |        |  |
| REFERENCES:                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                         |   |   |   |        |  |
| 1.                                                                                                                                                                                                                                                                                                                                                                              | "Marine Pollution R.B. Clark, C. Frid and M Attrill, Oxford Science Publications, 5th Edition, 2017.                                    |   |   |   |        |  |
| 2.                                                                                                                                                                                                                                                                                                                                                                              | Marine Pollution: New Research - Tobias N. Hofer, Nova Publishers, 2018,                                                                |   |   |   |        |  |
| 3.                                                                                                                                                                                                                                                                                                                                                                              | Laws, E.A., "Aquatic pollution", an introductory text. John Wiley and Sons, Inc., New York, 2000.                                       |   |   |   |        |  |
| 4.                                                                                                                                                                                                                                                                                                                                                                              | Practical Handbook of Estuarine and Marine Pollution, Michael J. Kennish, Volume 10 of CRC Marine Science, CRC Press, 1996.             |   |   |   |        |  |

| <b>COURSE OUTCOMES:</b>                                   |                                                                                                                                                 | <b>BT Mapped (Highest Level)</b> |
|-----------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|
| On completion of the course, the students will be able to |                                                                                                                                                 |                                  |
| CO1:                                                      | Know about the different components of marine environment.                                                                                      | Understand                       |
| CO2:                                                      | Understand physical concepts lying behind the tides, waves, and oceanic currents and natural processes of various activities happening over the | Understand                       |

  
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|                                                                   |                                                                                                 |     |     |     |     |     |     |     |     |      |          |          |      |      |      |  |
|-------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|------|----------|----------|------|------|------|--|
|                                                                   | marine environment                                                                              |     |     |     |     |     |     |     |     |      |          |          |      |      |      |  |
| CO3:                                                              | Identify and measure the marine pollution levels and effects                                    |     |     |     |     |     |     |     |     |      |          | Analyze  |      |      |      |  |
| CO4:                                                              | Apply the knowledge of remote sensing and GIS for monitoring marine environment water quality., |     |     |     |     |     |     |     |     |      |          | Apply    |      |      |      |  |
| CO5:                                                              | Develop marine pollution control measures.                                                      |     |     |     |     |     |     |     |     |      |          | Analyze  |      |      |      |  |
| Mapping of COs with POs and PSOs                                  |                                                                                                 |     |     |     |     |     |     |     |     |      |          |          |      |      |      |  |
| COs/POs                                                           | PO1                                                                                             | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO1<br>1 | PO1<br>2 | PSO1 | PSO2 | PSO3 |  |
| CO1                                                               | 1                                                                                               | 1   | 2   | -   | -   | -   | -   | -   | -   | -    | -        | -        | 2    | 2    | 2    |  |
| CO2                                                               | 2                                                                                               | 1   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | -        | 3    | 2    | 1    |  |
| CO3                                                               | 2                                                                                               | 1   | 2   | -   | -   | -   | -   | -   | -   | -    | -        | -        | 3    | 1    | 1    |  |
| CO4                                                               | 2                                                                                               | 2   | 2   | -   | -   | -   | -   | -   | -   | -    | -        | -        | 2    | 1    | 2    |  |
| CO5                                                               | 3                                                                                               | 2   | 2   | -   | -   | -   | -   | -   | -   | -    | -        | -        | 3    | 1    | 1    |  |
| Avg.                                                              | 2                                                                                               | 2   | 2   | -   | -   | -   | -   | -   | -   | -    | -        | -        | 3    | 1    | 1    |  |
| 1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom’s Taxonomy |                                                                                                 |     |     |     |     |     |     |     |     |      |          |          |      |      |      |  |

  
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|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|---------------------------|
| PEVE2414                                                                                                                                                                                                                                                                                                                                  | CLIMATE CHANGE AND MODELING                                                                                                                          |   |   |   |                           |
|                                                                                                                                                                                                                                                                                                                                           | Category                                                                                                                                             | L | T | P | Credit                    |
|                                                                                                                                                                                                                                                                                                                                           | PEC                                                                                                                                                  | 3 | 0 | 0 | 3                         |
| Course objectives                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                      |   |   |   |                           |
|                                                                                                                                                                                                                                                                                                                                           | ● To introduce the emerging concepts of climate modelling and projecting future climate change, understand data analysis and application.            |   |   |   |                           |
| UNIT – I                                                                                                                                                                                                                                                                                                                                  | CLIMATE CHANGE AND CLIMATE VARIABILITY                                                                                                               |   |   |   | 9                         |
| Introduction- atmosphere - weather and climate - climate parameters (Temperature, Rainfall, Humidity, Wind etc.,) Equations governing the atmosphere - numerical weather prediction models - introduction to GCMs - applications in climate change projections.                                                                           |                                                                                                                                                      |   |   |   |                           |
| UNIT – II                                                                                                                                                                                                                                                                                                                                 | IPCC CLIMATE SCENARIOS                                                                                                                               |   |   |   | 9                         |
| Intergovernmental PANEL on Climate Change (IPCC) - an overview - key assumptions – Representative Concentration Pathways (RCP 2.6, 4.5, 6.0, 8.5)                                                                                                                                                                                         |                                                                                                                                                      |   |   |   |                           |
| UNIT – III                                                                                                                                                                                                                                                                                                                                | GLOBAL CLIMATE MODEL AND REGIONAL CLIMATE MODEL                                                                                                      |   |   |   | 9                         |
| Climate model – types of model- General Circulation Models (GCM) - Issues with GCMs - Introduction to RCMs and LAMs - RCMs modellers -advantages and disadvantages of GCMs and RCMs                                                                                                                                                       |                                                                                                                                                      |   |   |   |                           |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                 | DOWNSCALING GLOBAL CLIMATE MODEL - AN OVERVIEW                                                                                                       |   |   |   | 9                         |
| Need for downscaling - selection of GCMs for regional climate change studies - ensemble theory selection of ensembles, model domain (Spatial domain and temporal domain), Resolution and climate variables - lateral boundary conditions - methods of downscaling (Statistical and Dynamical) - examples from each and their limitations. |                                                                                                                                                      |   |   |   |                           |
| UNIT – V                                                                                                                                                                                                                                                                                                                                  | ANALYSIS AND POST PROCESSING                                                                                                                         |   |   |   | 9                         |
| Model validation and calibration- evaluating model performance- post processing - introduction to analysis tools - Ferret, R, Grads, IDL, SPSS, ArcGIS - climate change impact – vulnerability assessment-case studies- Adaptation strategies                                                                                             |                                                                                                                                                      |   |   |   |                           |
|                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                      |   |   |   | Total: 45 periods         |
| REFERENCES:                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                      |   |   |   |                           |
| 1.                                                                                                                                                                                                                                                                                                                                        | IPCC Fifth Assessment Report, Cambridge University Press, Cambridge, UK, 2013                                                                        |   |   |   |                           |
| 2.                                                                                                                                                                                                                                                                                                                                        | Neelin David J, “Climate Change and Climate Modelling”, Cambridge University Press 2011                                                              |   |   |   |                           |
| 3.                                                                                                                                                                                                                                                                                                                                        | Kendal McGuffie, Ann Henderson, “A Climate Modelling” Primer 3rd Edition, John Wiley & Sons, Ltd, Chichester, UK 2005                                |   |   |   |                           |
| 4.                                                                                                                                                                                                                                                                                                                                        | Thomas Stocker, “Introduction to Climate Modelling”, Advances in Geophysical and Environmental Mechanics and Mathematics. Springer Publication, 2011 |   |   |   |                           |
| 5.                                                                                                                                                                                                                                                                                                                                        | David Archer, ‘Global warming-Understanding the forecast’, Blackwell publishing, 2007                                                                |   |   |   |                           |
| COURSE OUTCOMES:                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                      |   |   |   | BT Mapped (Highest Level) |
| On completion of the course, the students will be able to                                                                                                                                                                                                                                                                                 |                                                                                                                                                      |   |   |   |                           |
| CO1:                                                                                                                                                                                                                                                                                                                                      | Understand the basics of climate change and variability                                                                                              |   |   |   | Understand                |
| CO2:                                                                                                                                                                                                                                                                                                                                      | Comprehend the latest IPCC climate scenarios                                                                                                         |   |   |   | Understand                |
| CO3:                                                                                                                                                                                                                                                                                                                                      | Gain in-depth knowledge on climate models                                                                                                            |   |   |   | Understand                |
| CO4:                                                                                                                                                                                                                                                                                                                                      | Downscale of climate scenarios through different modelling techniques, and validate climate models.                                                  |   |   |   | Analyze                   |
| CO5:                                                                                                                                                                                                                                                                                                                                      | Post process the model outputs for climate impact assessment, know about adaptation strategies                                                       |   |   |   | Analyze                   |

  
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| Mapping of COs with POs and PSOs                                 |     |     |     |     |     |     |     |     |     |      |          |          |      |      |      |
|------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|----------|----------|------|------|------|
| COs/POs                                                          | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO1<br>1 | PO1<br>2 | PSO1 | PSO2 | PSO3 |
| CO1                                                              | 1   | 1   | 2   | -   | -   | -   | -   | -   | -   | -    | -        | -        | 1    | 1    | 1    |
| CO2                                                              | 1   | 2   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | -        | 2    | 2    | 2    |
| CO3                                                              | 2   | 1   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | -        | 3    | 1    | 1    |
| CO4                                                              | 3   | 1   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | -        | 3    | 1    | 1    |
| CO5                                                              | 3   | 1   | 1   | -   | -   | -   | -   | -   | -   | -    | -        | -        | 2    | 2    | 1    |
| Avg.                                                             | 2   | 1   | 2   | -   | -   | -   | -   | -   | -   | -    | -        | -        | 3    | 2    | 1    |
| 1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom's Taxonomy |     |     |     |     |     |     |     |     |     |      |          |          |      |      |      |

  
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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                 |   |   |   |        |
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| PEVE2415                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | OPERATION AND MAINTENANCE OF WATER AND WASTEWATER TREATMENT SYSTEMS                                                                                                                             |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Category                                                                                                                                                                                        | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | PEC                                                                                                                                                                                             | 3 | 0 | 0 | 3      |
| Course objectives                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                 |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | ● To educate the student on the various operation & maintenance aspects of water treatment systems, sewer systems, sewage treatment plants and effluent treatment plants.                       |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | ELEMENTS OF OPERATION AND MAINTENANCE                                                                                                                                                           |   |   |   | 9      |
| Strategy for good operation and maintenance- preventive and corrective maintenance scheduling - operation and maintenance Plan - proper and adequate tools, spare units and parts – training requirements- laboratory control- records and reports- housekeeping –sampling procedure analytical techniques- code of practice for analytical laboratories- measurement of flows, pressures and Levels -safety in O&M operations - management information system - measures for conservation of energy                                                                                                          |                                                                                                                                                                                                 |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | OPERATION AND MAINTENANCE OF WATER SUPPLY SYSTEMS                                                                                                                                               |   |   |   | 9      |
| Operational problems, O&M practices and records of operation of reservoir and intakes - causes of failure of wells- rehabilitation of tube wells & bore wells- prevention of incrustation and corrosion - problems in transmission mains- maintenance of pipelines and leakage control- repair method for different types of pipes- preventive and corrective maintenance of water pumps - problems in the water distribution system and remedies- water quality monitoring and surveillance                                                                                                                  |                                                                                                                                                                                                 |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | OPERATION AND MAINTENANCE OF SEWERAGE SYSTEMS                                                                                                                                                   |   |   |   | 9      |
| Components and functions of sewerage system – maintenance of collection system – operational problems– clogging of pipes – hazards – precautions against gas hazards – precautions against infections – devices for cleaning the conduits – preventive and corrective maintenance of sewage pumps –operation and maintenance of sewage pumping stations- maintenance hazards and operator protection –SOP-case studies                                                                                                                                                                                        |                                                                                                                                                                                                 |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | OPERATION AND MAINTENANCE OF PHYSICO-CHEMICAL TREATMENT UNITS                                                                                                                                   |   |   |   | 9      |
| Operation and maintenance in screen chamber, grit chamber and clarifiers- operation issues, trouble shooting guidelines and record keeping requirements for clarifier, equalization basins, neutralization unit - chemical storage and mixing equipment - chemical metering equipment - flash mixer –filters, thickeners and centrifuges- filter press - start-up and maintenance inspection - motors and pumps - hazards in chemical handling –jar test - chlorination equipment - membrane process systems- SDI and LSI determination- process chemistry and chemical dosage calculations- SOP-case studies |                                                                                                                                                                                                 |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | OPERATION AND MAINTENANCE OF BIOLOGICAL TREATMENT UNITS                                                                                                                                         |   |   |   | 9      |
| Construction, operation and maintenance aspects of activated sludge process, trickling filters, anaerobic digester, SBR, UASBR, MBRs- startup and shutdown procedures-DO, MLSS and SVI monitoring- trouble shooting guidelines –planning, organizing and controlling of plant operations – capacity building, case studies of retrofitting- SOP-case studies                                                                                                                                                                                                                                                  |                                                                                                                                                                                                 |   |   |   |        |
| Total: 45 periods                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                 |   |   |   |        |
| REFERENCES:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                 |   |   |   |        |
| 1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | CPHEEO , Manual on operation and maintenance of water supply systems, Central Public Health and Environmental Engineering Organisation, Ministry of Urban Development, Government of India 2013 |   |   |   |        |
| 2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Ministry of Drinking Water and Sanitation, operation and maintenance manual for rural water supplies, Government of India, 2013                                                                 |   |   |   |        |
| 3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Metcalf & Eddy, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater                                                                                                 |   |   |   |        |

  
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|    |                                                                                                                                                                         |
|----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | engineering, treatment and reuse, Fourth Edition, McGraw-Hill, 2017                                                                                                     |
| 4. | Ananth S Kodavasal, The STP Guide-Design, Operation and maintenance, Karnataka State Pollution Control Board, Bangalore, 2011                                           |
| 5. | Frik Schutte, handbook for the operation of water Treatment Works, The Water Research Commission, The Water Institute of Southern Africa, TT265/06, 2006.               |
| 6. | Michael D. Nelson, Chair, Operation of municipal waste water treatment plants, Water environment federation, vol.2 liquid process, 2007.                                |
| 7. | Michael D. Nelson, Chair, Operation of municipal waste water treatment plants, Water environment federation, vol.1 Management and support systems, sixth edition, 2007. |

| COURSE OUTCOMES:<br>On completion of the course, the students will be able to |                                                                          |     |     |     |     |     |     |     |     |      |          | BT Mapped (Highest Level) |      |      |      |
|-------------------------------------------------------------------------------|--------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|------|----------|---------------------------|------|------|------|
| CO1:                                                                          | Understand the O&M issues pertaining to STP and WTP                      |     |     |     |     |     |     |     |     |      |          | Understand                |      |      |      |
| CO2:                                                                          | Understand operation and maintenance of water intakes and supply systems |     |     |     |     |     |     |     |     |      |          | Understand                |      |      |      |
| CO3:                                                                          | Recognize the O&M issues relevant to sewerage system                     |     |     |     |     |     |     |     |     |      |          | Understand                |      |      |      |
| CO4:                                                                          | Understand operation and maintenance of physico-chemical treatment units |     |     |     |     |     |     |     |     |      |          | Understand                |      |      |      |
| CO5:                                                                          | Understand operation and maintenance of biological treatment units       |     |     |     |     |     |     |     |     |      |          | Understand                |      |      |      |
| Mapping of COs with POs and PSOs                                              |                                                                          |     |     |     |     |     |     |     |     |      |          |                           |      |      |      |
| COs/POs                                                                       | PO1                                                                      | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO1<br>1 | PO1<br>2                  | PSO1 | PSO2 | PSO3 |
| CO1                                                                           | 2                                                                        | 1   | 2   | -   | -   | -   | -   | -   | -   | -    | -        | -                         | 2    | 2    | 1    |
| CO2                                                                           | 1                                                                        | 2   | 2   | -   | -   | -   | -   | -   | -   | -    | -        | -                         | 3    | 2    | 1    |
| CO3                                                                           | 2                                                                        | 2   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | -                         | 3    | 2    | 1    |
| CO4                                                                           | 1                                                                        | 1   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | -                         | 3    | 3    | 1    |
| CO5                                                                           | 1                                                                        | 1   | 2   | -   | -   | -   | -   | -   | -   | -    | -        | -                         | 2    | 2    | 2    |
| Avg.                                                                          | 2                                                                        | 1   | 2   | -   | -   | -   | -   | -   | -   | -    | -        | -                         | 3    | 2    | 1    |
| 1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom’s Taxonomy             |                                                                          |     |     |     |     |     |     |     |     |      |          |                           |      |      |      |

  
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|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|-------------------|
| PEVE2416                                                                                                                                                                                                                                                                                                                                                                                                                    | AIR QUALITY MODELING                                                                                                                                                                                                               |   |   |   |                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                             | Category                                                                                                                                                                                                                           | L | T | P | Credit            |
|                                                                                                                                                                                                                                                                                                                                                                                                                             | PEC                                                                                                                                                                                                                                | 3 | 0 | 0 | 3                 |
| Course objectives                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                    |   |   |   |                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                             | ● To introduce the theory of dispersion of air pollution in the atmosphere and major approaches for air pollution modelling and to demonstrate the features of most widely used commercial and freely available air quality models |   |   |   |                   |
| UNIT – I                                                                                                                                                                                                                                                                                                                                                                                                                    | MODELLING AND MODELS                                                                                                                                                                                                               |   |   |   | 8                 |
| Overview of different types of models-deterministic and stochastic approach- steps in model development-numerical and simulations models- calibration and validation of models- limitations transport phenomena-mass balance analysis-model development and decision making. Types of air quality models-classification                                                                                                     |                                                                                                                                                                                                                                    |   |   |   |                   |
| UNIT – II                                                                                                                                                                                                                                                                                                                                                                                                                   | METEOROLOGY AND DISPERSION                                                                                                                                                                                                         |   |   |   | 11                |
| Chemistry of air Pollutants - atmospheric reactions, sinks for air pollution –transport of air pollutants - meteorological factors for dispersal of air pollutants – meteorological modelling-developing wind Chemistry of air Pollutants - atmospheric reactions, sinks for air pollution –transport of air pollutants - meteorological factors for dispersal of air pollutants – meteorological modelling-developing wind |                                                                                                                                                                                                                                    |   |   |   |                   |
| UNIT – III                                                                                                                                                                                                                                                                                                                                                                                                                  | EMISSION AND SOURCE DISPERSION MODELS                                                                                                                                                                                              |   |   |   | 10                |
| modeling for reactive and nonreactive pollutants, point source-single and multiple sources- area sources, line source models, fixed box models- diffusion models – Gaussian plume derivation modifications of Gaussian plume equation- Gaussian puff model- emission models-emission factors long term average-multiple cell model-accuracy and utilization-limitations-air quality mapping                                 |                                                                                                                                                                                                                                    |   |   |   |                   |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                                                                                                   | RECEPTOR MODELS AND INDOOR AIR QUALITY MODELS                                                                                                                                                                                      |   |   |   | 8                 |
| Receptor models- source apportionment studies- CMB model- PMF models; environmental wind tunnel models; indoor air pollutants –mass balance-single compartment-multiple compartments calculation of deposition velocity and Position of Particles-Aerosol-Odours and sick building syndrome-Integrated Models.                                                                                                              |                                                                                                                                                                                                                                    |   |   |   |                   |
| UNIT – V                                                                                                                                                                                                                                                                                                                                                                                                                    | SOFTWARE PACKAGE APPLICATIONS                                                                                                                                                                                                      |   |   |   | 8                 |
| Commercial air quality models - ADMS, AERMOD, CALINE, CALPUFF, DEGADIS, HYROAD, INDUSTRIAL SOURCE COMPLEX, SCREEN, HYSPLIT, INDEX                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                    |   |   |   |                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                    |   |   |   | Total: 45 periods |
| REFERENCES:                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                    |   |   |   |                   |
| 1.                                                                                                                                                                                                                                                                                                                                                                                                                          | Noel de Nevers, "Air Pollution Control Engg"., Mc Graw Hill, New York, 2016.                                                                                                                                                       |   |   |   |                   |
| 2.                                                                                                                                                                                                                                                                                                                                                                                                                          | Arthur C.Stern, "Air Pollution (Vol.I – Vol.VIII)", Academic Press, 2006.                                                                                                                                                          |   |   |   |                   |
| 3.                                                                                                                                                                                                                                                                                                                                                                                                                          | Lawrence K. Wang, Norman C. Parelra, Yung Tse Hung, "Air Pollution Control Engineering", Tokyo, 2004                                                                                                                               |   |   |   |                   |
| 4.                                                                                                                                                                                                                                                                                                                                                                                                                          | John H. Seinfeld and Spyros N. Pandis Atmospheric Chemistry and Physics: From Air Pollution to Climate Change, 2 nd Edition, , 2006,                                                                                               |   |   |   |                   |
| 5.                                                                                                                                                                                                                                                                                                                                                                                                                          | Mark Z. Jacobson Fundamentals of Atmospheric Modeling, 2 nd Edition, 2005,                                                                                                                                                         |   |   |   |                   |
| 6.                                                                                                                                                                                                                                                                                                                                                                                                                          | Deaton and Wine Brake, "Dynamic Modeling of Environmental Systems", Wiley & Sons, 2002.                                                                                                                                            |   |   |   |                   |

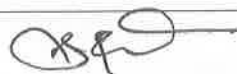
|                                                           |                                                                                       |                                  |
|-----------------------------------------------------------|---------------------------------------------------------------------------------------|----------------------------------|
| <b>COURSE OUTCOMES:</b>                                   |                                                                                       | <b>BT Mapped (Highest Level)</b> |
| On completion of the course, the students will be able to |                                                                                       |                                  |
| CO1:                                                      | Concepts and types of models, model development, their applicability and limitations. | Understand                       |

  
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|-------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|------|----------|------------|------|------|------|
| CO2:                                                              | Understand the physicochemical transformation of air pollutants in the atmosphere along with the meteorological influence in dispersion of pollutants. |     |     |     |     |     |     |     |     |      |          | Understand |      |      |      |
| CO3:                                                              | Identifies emission source and applies suitable modeling tools to estimate the impact of the pollutants.                                               |     |     |     |     |     |     |     |     |      |          | Apply      |      |      |      |
| CO4:                                                              | Fetch knowledge on source inventories, model prediction efficiency and potential risk assessment.                                                      |     |     |     |     |     |     |     |     |      |          | Understand |      |      |      |
| CO5:                                                              | Understand the application of models to predicts the air quality scenarios for different conditions and find suitable mitigation measures.             |     |     |     |     |     |     |     |     |      |          | Analyze    |      |      |      |
| Mapping of COs with POs and PSOs                                  |                                                                                                                                                        |     |     |     |     |     |     |     |     |      |          |            |      |      |      |
| COs/POs                                                           | PO1                                                                                                                                                    | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO1<br>1 | PO1<br>2   | PSO1 | PSO2 | PSO3 |
| CO1                                                               | 2                                                                                                                                                      | 2   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | -          | 3    | 1    | 1    |
| CO2                                                               | 3                                                                                                                                                      | 2   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | -          | 3    | 1    | 1    |
| CO3                                                               | 3                                                                                                                                                      | 1   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | -          | 3    | 3    | 2    |
| CO4                                                               | 3                                                                                                                                                      | 1   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | -          | 2    | 2    | 2    |
| CO5                                                               | 3                                                                                                                                                      | 1   | 2   | -   | -   | -   | -   | -   | -   | -    | -        | -          | 3    | 2    | 1    |
| Avg.                                                              | 3                                                                                                                                                      | 1   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | -          | 3    | 2    | 1    |
| 1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom’s Taxonomy |                                                                                                                                                        |     |     |     |     |     |     |     |     |      |          |            |      |      |      |

  
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|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|--------|
| PEVE2417                                                                                                                                                                                                                                                                                                                                                             | FATE AND REMEDIATION OF EMERGING CONTAMINANTS                                                                                                                                                                                                                                                                                                            |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                      | Category                                                                                                                                                                                                                                                                                                                                                 | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                                                                                      | PEC                                                                                                                                                                                                                                                                                                                                                      | 3 | 0 | 0 | 3      |
| Course objectives                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                          |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                      | ● To impart knowledge on the priority list of emerging contaminants and improve understanding of their sources, occurrence, distribution, existing regulations/policies, analysis and screening techniques, environmental fate, transport, underlying mechanisms, modelling frameworks, ecotoxicity, risk assessment tools and remediation technologies. |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                                                                                                                             | SOURCES, OCCURRENCE AND REGULATORY REQUIREMENTS                                                                                                                                                                                                                                                                                                          |   |   |   | 9      |
| Definition - Priority vs. emerging contaminants - recent concerns - major groups - examples - properties - sources - occurrence - distribution in soils, groundwater, industrial and municipal wastewaters, aquaculture effluents, freshwater and marine ecosystems, air, food, plants, animals and human blood - existing global regulatory frameworks and policies |                                                                                                                                                                                                                                                                                                                                                          |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                                                                                                                            | CHARACTERIZATION AND INSTRUMENTATION                                                                                                                                                                                                                                                                                                                     |   |   |   | 7      |
| Sampling – sample preparation methods – analytical protocols for detection of pharmaceuticals, personal care products, antimicrobials and antibiotics, hormones, phthalate plasticizers and degradation products, surfactants, brominated fire retardants, pesticides and nanoparticles – analytical instruments                                                     |                                                                                                                                                                                                                                                                                                                                                          |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                                                                                                                           | ENVIRONMENTAL FATE AND TRANSPORT                                                                                                                                                                                                                                                                                                                         |   |   |   | 9      |
| Sorption - leaching - runoff - erosion - volatilization - plant/animal uptake - degradation and transformation - human health and ecological risks - environmental fate modelling frameworks – risk assessment tools - challenges - biomonitoring and biosensors                                                                                                     |                                                                                                                                                                                                                                                                                                                                                          |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                                            | REMEDICATION TECHNOLOGIES                                                                                                                                                                                                                                                                                                                                |   |   |   | 13     |
| Incineration - sonolysis - multi-phase extraction - permeable reactive barrier - advanced oxidation processes - membrane based separation - nanofiltration - Reverse osmosis - biosorption - bioaugmentation - combined treatment options - remediation endpoints - challenges - opportunities                                                                       |                                                                                                                                                                                                                                                                                                                                                          |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                                                                                                                                             | CASE STUDIES                                                                                                                                                                                                                                                                                                                                             |   |   |   | 7      |
| Occurrence in different environmental compartments - environmental fate and transport – potential and known risks to human health and the environment - effective technological and policy approaches to prevent, control and remove emerging pollutants in the environment                                                                                          |                                                                                                                                                                                                                                                                                                                                                          |   |   |   |        |
| Total: 45 periods                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                          |   |   |   |        |
| REFERENCES:                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                          |   |   |   |        |
| 1.                                                                                                                                                                                                                                                                                                                                                                   | Alok Bhandari, Rao Y. Surampalli, Craig D. Adams, Pascale Champagne, Say Kee Ong, R. D. Tyagi and Tian Zhang, Contaminants of Emerging Environmental Concern, American Society of Civil Engineers, US, 2009.                                                                                                                                             |   |   |   |        |
| 2.                                                                                                                                                                                                                                                                                                                                                                   | Caitlin H. Bell, Margaret Gentile, Erica Kalve, Ia Ross, John Horst and Suthan Suthersan, Emerging Contaminants Handbook, CRC Press, US, First edition, 2018.                                                                                                                                                                                            |   |   |   |        |
| 3.                                                                                                                                                                                                                                                                                                                                                                   | Damia Barcelo and Mira Petrovic, Emerging Contaminants from Industrial and Municipal Waste Removal Technologies, Springer, Germany, 2012.                                                                                                                                                                                                                |   |   |   |        |
| 4.                                                                                                                                                                                                                                                                                                                                                                   | Damia Barcelo, Emerging Organic Contaminants and Human Health, Springer, Germany, 2012.                                                                                                                                                                                                                                                                  |   |   |   |        |
| 5.                                                                                                                                                                                                                                                                                                                                                                   | Francisco G, Calvo-Flores, Joaquin Isac-Garcia, Jose A. Dobado, Emerging Pollutants: Origin, Structure and Properties, Wiley & Sons, US, 2018.                                                                                                                                                                                                           |   |   |   |        |
| 6.                                                                                                                                                                                                                                                                                                                                                                   | Giusy Lofrano, Emerging Compounds Removal from Wastewater Natural and Solar Based Treatments, Springer, Germany, 2012                                                                                                                                                                                                                                    |   |   |   |        |



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|-------------------------------------------------------------------|---------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|------|----------|------------|------|------|------|
|                                                                   | identify, formulate, and solve complex environmental engineering problems |     |     |     |     |     |     |     |     |      |          |            |      |      |      |
| CO2:                                                              | Understand interaction of pollutants in environment                       |     |     |     |     |     |     |     |     |      |          | Understand |      |      |      |
| CO3:                                                              | Understand reactor behavior and transformation of contaminants            |     |     |     |     |     |     |     |     |      |          | Understand |      |      |      |
| CO4:                                                              | Conceptualize mass transport phenomina                                    |     |     |     |     |     |     |     |     |      |          | Analyze    |      |      |      |
| CO5:                                                              | Apply reaction engineering concept in biological treatment system         |     |     |     |     |     |     |     |     |      |          | Apply      |      |      |      |
| Mapping of COs with POs and PSOs                                  |                                                                           |     |     |     |     |     |     |     |     |      |          |            |      |      |      |
| COs/POs                                                           | PO1                                                                       | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO1<br>1 | PO1<br>2   | PSO1 | PSO2 | PSO3 |
| CO1                                                               | 3                                                                         | 2   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | -          | 3    | 1    | 1    |
| CO2                                                               | 3                                                                         | 2   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | -          | 2    | 1    | 2    |
| CO3                                                               | 3                                                                         | 1   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | -          | 3    | 1    | 1    |
| CO4                                                               | 2                                                                         | 1   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | -          | 2    | 1    | 1    |
| CO5                                                               | 3                                                                         | 1   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | -          | 2    | 2    | 1    |
| Avg.                                                              | 3                                                                         | 1   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | -          | 3    | 2    | 1    |
| 1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom’s Taxonomy |                                                                           |     |     |     |     |     |     |     |     |      |          |            |      |      |      |

  
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| PEVE2419                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>MEMBRANE SEPARATION FOR WATER AND WASTEWATER TREATMENT</b>                                                                                                                                                                                             |          |          |          |                          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>Category</b>                                                                                                                                                                                                                                           | <b>L</b> | <b>T</b> | <b>P</b> | <b>Credit</b>            |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>PEC</b>                                                                                                                                                                                                                                                | <b>3</b> | <b>0</b> | <b>0</b> | <b>3</b>                 |
| Course objectives                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                           |          |          |          |                          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | ● To introduce the principles and design of different membrane separation technologies including microfiltration, ultrafiltration, nanofiltration, reverse osmosis, electrodialysis and membrane bioreactor processes for water and wastewater treatment. |          |          |          |                          |
| <b>UNIT – I</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>MEMBRANE FILTRATION PROCESSES</b>                                                                                                                                                                                                                      |          |          |          | <b>10</b>                |
| Membrane filtration for solid Liquid separation - cross flow filtration - theory of membrane separation – mass transport characteristics - concentration polarisation – membrane flux and trans membrane pressure -types and choice of membranes- porous, nonporous, symmetric and assymmetric – membrane structures and materials - plate and frame, spiral wound and hollow fibre membranes – membrane performance factors and considerations - membrane manufacturing process.                                                                     |                                                                                                                                                                                                                                                           |          |          |          |                          |
| <b>UNIT – II</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>MEMBRANE SYSTEMS</b>                                                                                                                                                                                                                                   |          |          |          | <b>10</b>                |
| Membrane module/element designs – membrane system components – design of membrane systems - design of modules, assembly, plant process control and applications - design and applications of low pressure membrane technology systems-microfiltration and ultrafiltration- design and applications of diffusive membrane technologies- nanofiltration and reverse osmosis -- electro dialysis : Ion exchange membranes, process design- design of membrane systems - pump types and pump selection – plant operations – economics of membrane systems |                                                                                                                                                                                                                                                           |          |          |          |                          |
| <b>UNIT – III</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>MEMBRANE BIOREACTORS</b>                                                                                                                                                                                                                               |          |          |          | <b>8</b>                 |
| Historical perspective of MBRs- biotreatment fundamentals- MBR principles and fundamentals- MBR design principles, design assignment, alternative MBR configurations – commercial technologies- fouling and fouling control- case studies                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                           |          |          |          |                          |
| <b>UNIT – IV</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>PRETREATMENT AND POST TREATMENT SYSTEMS</b>                                                                                                                                                                                                            |          |          |          | <b>8</b>                 |
| Membrane fouling – source water quality characterization- particulate membrane foulants – mineral membrane-scaling foulants - natural*organic foulants- microbial foulants- parameters and measurement methods- Langlier index, silt density index -combined impacts of various types of foulants- control of fouling -pretreatment methods and strategies –source water screening and conditioning- pretreatment by sand and membrane filtration- monitoring of pretreatment –chemical cleaning systems- biofoulant control – post treatment systems |                                                                                                                                                                                                                                                           |          |          |          |                          |
| <b>UNIT – V</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>CASE STUDIES</b>                                                                                                                                                                                                                                       |          |          |          | <b>9</b>                 |
| Case studies on the design of membrane based water and wastewater treatment systems – zero liquid effluent discharge plants – desalination of brackish water and seawater – project implementation and project economics – environmental issues –reject management –energy recovery systems                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                           |          |          |          |                          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                           |          |          |          | <b>Total: 45 periods</b> |
| <b>REFERENCES:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                           |          |          |          |                          |
| 1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Mihir K. Purkait, Randeep Singh, Membrane Technology in Separation Science, CRC Press, 2018                                                                                                                                                               |          |          |          |                          |
| 2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Anthony Wachinski, Membrane Processes for water reuse, McGraw-Hill, Newyork, 2013                                                                                                                                                                         |          |          |          |                          |
| 3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Nikolay Voutchkov, Desalination Engineering-Planning and Design, McGraw-Hill, Newyork, 2013                                                                                                                                                               |          |          |          |                          |
| 4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Symon Jud, MBR Book – "Principles and application of MBR in water and wastewater treatment", Elsevier, 2010.                                                                                                                                              |          |          |          |                          |
| 5.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | A.F. Ismail, Takeshi Matsuura, Membrane Technology for Water and Wastewater Treatment, Energy and Environment, CRC Press, 2016                                                                                                                            |          |          |          |                          |
| 6.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Kaustubha Mohanty, Mihir K. Purkait, Membrane Technologies and Applications, CRC Press, 2011                                                                                                                                                              |          |          |          |                          |

  
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|    |                                                                                                                                                                    |
|----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7. | Baker, R. W., "Membrane technology and applications", 2nd .. John Wiley 2012                                                                                       |
| 8. | Metcalf & Eddy, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater engineering, treatment and reuse fourth Edition, McGraw-Hill, 2017 |

| COURSE OUTCOMES:<br>On completion of the course, the students will be able to |                                                                                                                                                                                                            |     |     |     |     |     |     |     |     |      |          | BT Mapped (Highest Level) |      |      |      |
|-------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|------|----------|---------------------------|------|------|------|
| CO1:                                                                          | Explain the various main membrane processes, principles, separation mechanisms, and applications                                                                                                           |     |     |     |     |     |     |     |     |      |          | Understand                |      |      |      |
| CO2:                                                                          | Apply the knowledge of science and engineering fundamentals to analyse the mechanisms of membrane filtration                                                                                               |     |     |     |     |     |     |     |     |      |          | Analyze                   |      |      |      |
| CO3:                                                                          | Design of membrane systems involving microfiltration, ultrafiltration, nanofiltration, reverse osmosis, electrodialysis and membrane bioreactor processes                                                  |     |     |     |     |     |     |     |     |      |          | Analyze                   |      |      |      |
| CO4:                                                                          | Select appropriate membrane technologies for water and wastewater treatment taking into account the impact of the solutions in a sustainability context                                                    |     |     |     |     |     |     |     |     |      |          | Analyze                   |      |      |      |
| CO5:                                                                          | Conduct research pertinent to membrane technology applications to water and wastewater treatment and communicate effectively to different stakeholders as well as engage in independent life-long learning |     |     |     |     |     |     |     |     |      |          | Analyze                   |      |      |      |
| Mapping of COs with POs and PSOs                                              |                                                                                                                                                                                                            |     |     |     |     |     |     |     |     |      |          |                           |      |      |      |
| COs/POs                                                                       | PO1                                                                                                                                                                                                        | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO1<br>1 | PO1<br>2                  | PSO1 | PSO2 | PSO3 |
| CO1                                                                           | 1                                                                                                                                                                                                          | 1   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | -                         | 3    | 2    | 1    |
| CO2                                                                           | 3                                                                                                                                                                                                          | 1   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | -                         | 3    | 2    | 1    |
| CO3                                                                           | 2                                                                                                                                                                                                          | 3   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | -                         | 2    | 1    | 1    |
| CO4                                                                           | 3                                                                                                                                                                                                          | 1   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | -                         | 3    | 3    | 1    |
| CO5                                                                           | 2                                                                                                                                                                                                          | 3   | 2   | -   | -   | -   | -   | -   | -   | -    | -        | -                         | 2    | 2    | 3    |
| Avg.                                                                          | 3                                                                                                                                                                                                          | 2   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | -                         | 3    | 2    | 1    |

1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom’s Taxonomy

1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy



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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                            |   |   |        |                                                                                                                                                    |          |   |   |   |        |    |   |   |   |   |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|--------|----------------------------------------------------------------------------------------------------------------------------------------------------|----------|---|---|---|--------|----|---|---|---|---|
| PEVO2414                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | RENEWABLE ENERGY TECHNOLOGY                                                                                                                                                                                |   |   |        |                                                                                                                                                    |          |   |   |   |        |    |   |   |   |   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                            |   |   |        | <table><tr><td>Category</td><td>L</td><td>T</td><td>P</td><td>Credit</td></tr><tr><td>OE</td><td>3</td><td>0</td><td>0</td><td>3</td></tr></table> | Category | L | T | P | Credit | OE | 3 | 0 | 0 | 3 |
| Category                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | L                                                                                                                                                                                                          | T | P | Credit |                                                                                                                                                    |          |   |   |   |        |    |   |   |   |   |
| OE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 3                                                                                                                                                                                                          | 0 | 0 | 3      |                                                                                                                                                    |          |   |   |   |        |    |   |   |   |   |
| Course objectives                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                            |   |   |        |                                                                                                                                                    |          |   |   |   |        |    |   |   |   |   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | To impart knowledge on <ul style="list-style-type: none"><li>Different types of renewable energy technologies</li><li>Standalone operation, grid connected operation of renewable energy systems</li></ul> |   |   |        |                                                                                                                                                    |          |   |   |   |        |    |   |   |   |   |
| UNIT – I                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | INTRODUCTION                                                                                                                                                                                               |   |   |        | 9                                                                                                                                                  |          |   |   |   |        |    |   |   |   |   |
| Classification of energy sources – Co2 Emission - Features of Renewable energy - Renewable energy scenario in India -Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment Per Capital Consumption - CO2 Emission - importance of renewable energy sources, Potentials – Achievements– Applications.                                                                                                                              |                                                                                                                                                                                                            |   |   |        |                                                                                                                                                    |          |   |   |   |        |    |   |   |   |   |
| UNIT – II                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | SOLAR PHOTOVOLTAICS                                                                                                                                                                                        |   |   |        | 9                                                                                                                                                  |          |   |   |   |        |    |   |   |   |   |
| Solar Energy: Sun and Earth-Basic Characteristics of solar radiation- angle of sunrays on solar collector- Estimating Solar Radiation Empirically - Equivalent circuit of PV Cell- Photovoltaic cell characteristics: P-V and I-V curve of cell-Impact of Temperature and Insolation on I-V characteristics Shading Impacts on I-V characteristics-Bypass diode -Blocking diode.                                                                                                       |                                                                                                                                                                                                            |   |   |        |                                                                                                                                                    |          |   |   |   |        |    |   |   |   |   |
| UNIT – III                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | PHOTOVOLTAIC SYSTEM DESIGN                                                                                                                                                                                 |   |   |        | 9                                                                                                                                                  |          |   |   |   |        |    |   |   |   |   |
| Block diagram of solar photo voltaic system : Line commutated converters (inversion mode) - Boost and buck-boost converters - selection of inverter, battery sizing, array sizing - PV systems classification-standalone PV systems - Grid tied and grid interactive inverters- grid connection issues.                                                                                                                                                                                |                                                                                                                                                                                                            |   |   |        |                                                                                                                                                    |          |   |   |   |        |    |   |   |   |   |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | WIND ENERGY CONVERSION SYSTEMS                                                                                                                                                                             |   |   |        | 9                                                                                                                                                  |          |   |   |   |        |    |   |   |   |   |
| Origin of Winds: Global and Local Winds- Aerodynamics of Wind turbine-Derivation of Betz’s limit Power available in wind-Classification of wind turbine: Horizontal Axis wind turbine and Vertical axis wind turbine- Aerodynamic Efficiency-Tip Speed-Ratio-Solidity-Blade Count-Power curve of wind turbine - Configurations of wind energy conversion systems: Type A, Type B, Type C and Type D Configurations- Grid connection Issues - Grid integrated SCIG and PMSG based WECS. |                                                                                                                                                                                                            |   |   |        |                                                                                                                                                    |          |   |   |   |        |    |   |   |   |   |
| UNIT – V                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | OTHER RENEWABLE ENERGY SOURCES                                                                                                                                                                             |   |   |        | 9                                                                                                                                                  |          |   |   |   |        |    |   |   |   |   |
| Qualitative study of different renewable energy resources: ocean, Biomass, Hydrogen energy systems, Fuel cells, Ocean Thermal Energy Conversion (OTEC), Tidal and wave energy, Geothermal Energy Resources.                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                            |   |   |        |                                                                                                                                                    |          |   |   |   |        |    |   |   |   |   |
| Total: 45 periods                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                            |   |   |        |                                                                                                                                                    |          |   |   |   |        |    |   |   |   |   |
| TEXT BOOK:                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                            |   |   |        |                                                                                                                                                    |          |   |   |   |        |    |   |   |   |   |
| REFERENCES:                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                            |   |   |        |                                                                                                                                                    |          |   |   |   |        |    |   |   |   |   |
| 1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Andrew Hoffman, Competitive Environmental Strategy - A Guide for the Changing Business Landscape, Island Press.                                                                                            |   |   |        |                                                                                                                                                    |          |   |   |   |        |    |   |   |   |   |
| 2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Stephen Doven, Environment and Sustainability Policy: Creation, Implementation, Evaluation, the Federation Press, 2005                                                                                     |   |   |        |                                                                                                                                                    |          |   |   |   |        |    |   |   |   |   |
| 3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Robert Brinkmann., Introduction to Sustainability, Wiley-Blackwell., 2016                                                                                                                                  |   |   |        |                                                                                                                                                    |          |   |   |   |        |    |   |   |   |   |
| 4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Niko Roorda., Fundamentals of Sustainable Development, 3rd Edn, Routledge, 2020                                                                                                                            |   |   |        |                                                                                                                                                    |          |   |   |   |        |    |   |   |   |   |
| 5.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Bhavik R Bakshi., Sustainable Engineering: Principles and Practice, Cambridge University Press, 2019                                                                                                       |   |   |        |                                                                                                                                                    |          |   |   |   |        |    |   |   |   |   |

| COURSE OUTCOMES:<br>The students completing the course will have |                                                                                                           |     |     |     |     |     |     |     |     |      |          | BT Mapped (Highest Level) |      |      |      |
|------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|------|----------|---------------------------|------|------|------|
| CO1:                                                             | Demonstrate the need for renewable energy sources.                                                        |     |     |     |     |     |     |     |     |      |          | Understand                |      |      |      |
| CO2:                                                             | Develop a stand-alone photo voltaic system and implement a maximum power point tracking in the PV system. |     |     |     |     |     |     |     |     |      |          | Understand                |      |      |      |
| CO3:                                                             | Design a stand-alone and Grid connected PV system.                                                        |     |     |     |     |     |     |     |     |      |          | Understand                |      |      |      |
| CO4:                                                             | Analyze the different configurations of the wind energy conversion systems.                               |     |     |     |     |     |     |     |     |      |          | Understand                |      |      |      |
| CO5:                                                             | Realize the basic of various available renewable energy sources.                                          |     |     |     |     |     |     |     |     |      |          | Understand                |      |      |      |
| Mapping of COs with POs and PSOs                                 |                                                                                                           |     |     |     |     |     |     |     |     |      |          |                           |      |      |      |
| COs/POs                                                          | PO1                                                                                                       | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO1<br>1 | PO1<br>2                  | PSO1 | PSO2 | PSO3 |
| CO1                                                              | 3                                                                                                         | 1   | 1   | -   | -   | -   | -   | -   | -   | -    | -        | 3                         | 1    | 3    | 3    |
| CO2                                                              | 3                                                                                                         | 3   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | 3                         | 2    | 1    | 3    |
| CO3                                                              | 2                                                                                                         | 2   | 1   | -   | -   | -   | -   | -   | -   | -    | -        | 3                         | 3    | 2    | 1    |
| CO4                                                              | 3                                                                                                         | 2   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | 3                         | 2    | 2    | 3    |
| CO5                                                              | 3                                                                                                         | 3   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | 3                         | 2    | 3    | 3    |
| Avg.                                                             | 3                                                                                                         | 2   | 3   | -   | -   | -   | -   | -   | -   | -    | -        | 3                         | 2    | 2    | 3    |
| 1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom’s Taxonomy |                                                                                                           |     |     |     |     |     |     |     |     |      |          |                           |      |      |      |

  
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| POE2401                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | IPR, BIOSAFETY AND ENTREPRENEURSHIP               |          |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                   | Category | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                   | OEC      | 3 | 0 | 0 | 3      |
| UNIT – I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | IPR                                               |          |   |   |   | 9      |
| Intellectual property rights – Origin of the patent regime – Early patents act & Indian pharmaceutical industry – Types of patents – Patent Requirements – Application preparation filing and prosecution – Patentable subject matter – Industrial design, Protection of GMO's IP as a factor in R&D,IP's of relevance to biotechnology and few case studies.                                                                                                                                                                                                                                                                                                                                                                                          |                                                   |          |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | AGREEMENTS, TREATIES AND PATENT FILING PROCEDURES |          |   |   |   | 9      |
| History of GATT Agreement – Madrid Agreement – Hague Agreement – WIPO Treaties –Budapest Treaty – PCT – Ordinary – PCT – Conventional – Divisional and Patent of Addition – Specifications – Provisional and complete – Forms and fees Invention in context of "prior art" –Patent databases – Searching International Databases – Country-wise patent searches (USPTO,espacenet(EPO) – PATENT Scope (WIPO) – IPO, etc National & PCT filing procedure – Time frame and cost – Status of the patent applications filed – Precautions while patenting – disclosure/non-disclosure – Financial assistance for patenting – Introduction to existing schemes Patent licensing and agreement Patent infringement – Meaning, scope, litigation, case studies |                                                   |          |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | BIOSAFETY                                         |          |   |   |   | 9      |
| Introduction – Historical Background – Introduction to Biological Safety Cabinets – Primary Containment for Biohazards – Biosafety Levels – Biosafety Levels of Specific Microorganisms – Recommended Biosafety Levels for Infectious Agents and Infected Animals – Biosafety guidelines – Government of India.                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                   |          |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | GENETICALLY MODIFIED ORGANISMS                    |          |   |   |   | 9      |
| Definition of GMOs & LMOs – Roles of Institutional Biosafety Committee – RCGM – GEAC etc. for GMO applications in food and agriculture – Environmental release of GMOs – Risk Analysis – Risk Assessment – Risk management and communication – Overview of National Regulations and relevant International Agreements including Cartegana Protocol.                                                                                                                                                                                                                                                                                                                                                                                                    |                                                   |          |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | ENTREPRENEURSHIP DEVELOPMENT                      |          |   |   |   | 9      |
| Introduction – Entrepreneurship Concept – Entrepreneurship as a career – Entrepreneurial personality – Characteristics of successful Entrepreneur – Factors affecting entrepreneurial growth –                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                   |          |   |   |   |        |

Entrepreneurial Motivation – Competencies – Mobility – Entrepreneurship Development Programmes (EDP) - Launching Of Small Enterprise - Definition, Characteristics – Relationship between small and large units – Opportunities for an Entrepreneurial career – Role of small enterprise in economic development – Problems of small scale industries – Institutional finance to entrepreneurs - Institutional support to entrepreneurs.

**Total: 45 periods**

**REFERENCES:**

1. Bouchoux, D.E., “Intellectual Property: The Law of Trademarks, Copyrights, Patents, and Trade Secrets for the Paralegal”, 3rd Edition, Delmar Cengage Learning, 2008.
2. Fleming, D.O. and Hunt, D.L., “Biological Safety: Principles and Practices”, 4th Edition, American Society for Microbiology, 2006.
3. Irish, V., “Intellectual Property Rights for Engineers”, 2nd Edition, The Institution of Engineering and Technology, 2005.
4. Mueller, M.J., “Patent Law”, 3rd Edition, Wolters Kluwer Law & Business, 2009.
5. Young, T., “Genetically Modified Organisms and Biosafety: A Background Paper for Decision-Makers and Others to Assist in Consideration of GMO Issues” 1st Edition, World Conservation Union, 2004.

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| POE2403                                                                                                                                                      |                                                                                                                        | ENVIRONMENTAL SUSTAINABILITY                                                                                                                                                                                                                                                                                                                           |   |   |   |        |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|--------|
|                                                                                                                                                              |                                                                                                                        | Category                                                                                                                                                                                                                                                                                                                                               | L | T | P | Credit |
|                                                                                                                                                              |                                                                                                                        | OE                                                                                                                                                                                                                                                                                                                                                     | 3 | 0 | 0 | 3      |
| Course objectives                                                                                                                                            |                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
|                                                                                                                                                              |                                                                                                                        | <ul style="list-style-type: none"><li>• To gain knowledge about Valuing the Environment.</li><li>• To understand the Sustainable Development.</li><li>• To understand the concepts of significance of biodiversity</li><li>• To understand the concepts of pollution impacts</li><li>• To understand the concepts of environmental economics</li></ul> |   |   |   |        |
| UNIT – I                                                                                                                                                     |                                                                                                                        | INTRODUCTION                                                                                                                                                                                                                                                                                                                                           |   |   |   | 9      |
| Valuing the Environment: Concepts, Valuing the Environment: Methods, Property Rights, Externalities, and Environmental Problems                              |                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| UNIT – II                                                                                                                                                    |                                                                                                                        | CONCEPT OF SUSTAINABILITY                                                                                                                                                                                                                                                                                                                              |   |   |   | 9      |
| Sustainable Development: Defining the Concept, the Population Problem, Natural Resource Economics: An Overview, Energy, Water, Agriculture                   |                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| UNIT – III                                                                                                                                                   |                                                                                                                        | SIGNIFICANCE OF BIODIVERSITY                                                                                                                                                                                                                                                                                                                           |   |   |   | 9      |
| Biodiversity, Forest Habitat, Commercially Valuable Species, Stationary - Source Local Air Pollution, Acid Rain and Atmospheric Modification, Transportation |                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| UNIT – IV                                                                                                                                                    |                                                                                                                        | POLLUTION IMPACTS                                                                                                                                                                                                                                                                                                                                      |   |   |   | 9      |
| Water Pollution, Solid Waste and Recycling, Toxic Substances and Hazardous Wastes, Global Warming.                                                           |                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| UNIT – V                                                                                                                                                     |                                                                                                                        | ENVIRONMENTAL ECONOMICS                                                                                                                                                                                                                                                                                                                                |   |   |   | 9      |
| Development, Poverty, and the Environment, Visions of the Future, Environmental economics and policy by Tom Tietenberg, Environmental Economics              |                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| Total: 45 periods                                                                                                                                            |                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| TEXT BOOK:                                                                                                                                                   |                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| REFERENCES:                                                                                                                                                  |                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| 1.                                                                                                                                                           | Andrew Hoffman, Competitive Environmental Strategy - A Guide for the Changing Business Landscape, Island Press.        |                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| 2.                                                                                                                                                           | Stephen Doven, Environment and Sustainability Policy: Creation, Implementation, Evaluation, the Federation Press, 2005 |                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| 3.                                                                                                                                                           | Robert Brinkmann., Introduction to Sustainability, Wiley-Blackwell., 2016                                              |                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| 4.                                                                                                                                                           | Niko Roorda., Fundamentals of Sustainable Development, 3rd Edn, Routledge, 2020                                        |                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| 5.                                                                                                                                                           | Bhavik R Bakshi., Sustainable Engineering: Principles and Practice, Cambridge University Press, 2019                   |                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |

8.11.12

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| COURSE OUTCOMES:<br>The students completing the course will have |                                                                  |     |     |     |     |     |     |     |     |      | BT Mapped (Highest Level) |          |      |      |      |
|------------------------------------------------------------------|------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|------|---------------------------|----------|------|------|------|
| CO1:                                                             | Identify the need and importance of Environmental Sustainability |     |     |     |     |     |     |     |     |      | Understand                |          |      |      |      |
| CO2:                                                             | Explain the various concept of sustainability                    |     |     |     |     |     |     |     |     |      | Understand                |          |      |      |      |
| CO3:                                                             | Describe the importance of Biodiversity                          |     |     |     |     |     |     |     |     |      | Understand                |          |      |      |      |
| CO4:                                                             | Describe the importance of pollution impacts                     |     |     |     |     |     |     |     |     |      | Understand                |          |      |      |      |
| CO5:                                                             | Explain the dynamics of environmental economics.                 |     |     |     |     |     |     |     |     |      | Understand                |          |      |      |      |
| Mapping of COs with POs and PSOs                                 |                                                                  |     |     |     |     |     |     |     |     |      |                           |          |      |      |      |
| COs/POs                                                          | PO1                                                              | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO1<br>1                  | PO1<br>2 | PSO1 | PSO2 | PSO3 |
| CO1                                                              | 3                                                                | 1   | 1   | -   | -   | -   | -   | -   | -   | -    | -                         | 3        | 1    | 3    | 3    |
| CO2                                                              | 3                                                                | 3   | 3   | -   | -   | -   | -   | -   | -   | -    | -                         | 3        | 2    | 1    | 3    |
| CO3                                                              | 2                                                                | 2   | 1   | -   | -   | -   | -   | -   | -   | -    | -                         | 3        | 3    | 2    | 1    |
| CO4                                                              | 3                                                                | 2   | 3   | -   | -   | -   | -   | -   | -   | -    | -                         | 3        | 2    | 2    | 3    |
| CO5                                                              | 3                                                                | 3   | 3   | -   | -   | -   | -   | -   | -   | -    | -                         | 3        | 2    | 3    | 3    |
| Avg.                                                             | 3                                                                | 2   | 3   | -   | -   | -   | -   | -   | -   | -    | -                         | 3        | 2    | 2    | 3    |
| 1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom’s Taxonomy |                                                                  |     |     |     |     |     |     |     |     |      |                           |          |      |      |      |

8.12.12  
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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|--------|
| POE2405                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | MACHINE LEARNING AND DEEP LEARNING                                                                                                                                                                                                                                                                                                                                                                                                                     |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Category                                                                                                                                                                                                                                                                                                                                                                                                                                               | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | OE                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 3 | 0 | 0 | 3      |
| Course objectives                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <p>The course is aimed at</p> <ul style="list-style-type: none"><li>• Understanding about the learning problem and algorithms</li><li>• Providing insight about neural networks</li><li>• Introducing the machine learning fundamentals and significance</li><li>• Enabling the students to acquire knowledge about pattern recognition.</li><li>• Motivating the students to apply deep learning algorithms for solving real life problems.</li></ul> |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | LEARNING PROBLEMS AND ALGORITHMS                                                                                                                                                                                                                                                                                                                                                                                                                       |   |   |   | 9      |
| Various paradigms of learning problems, Supervised, Semi-supervised and Unsupervised algorithms                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | NEURAL NETWORKS                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   | 9      |
| Differences between Biological and Artificial Neural Networks - Typical Architecture, Common Activation Functions, Multi-layer neural network, Linear Separability, Hebb Net, Perceptron, Adaline, Standard Back propagation Training Algorithms for Pattern Association - Hebb rule and Delta rule, Hetero associative, Auto associative, Kohonen Self Organising Maps, Examples of Feature Maps, Learning Vector Quantization, Gradient descent, Boltzmann Machine Learning. |                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | MACHINE LEARNING – FUNDAMENTALS & FEATURE SELECTIONS & CLASSIFICATIONS                                                                                                                                                                                                                                                                                                                                                                                 |   |   |   | 9      |
| Classifying Samples: The confusion matrix, Accuracy, Precision, Recall, F1- Score, the curse of dimensionality, training, testing, validation, cross validation, overfitting, under-fitting the data, early stopping, regularization, bias and variance. Feature Selection, normalization, dimensionality reduction, Classifiers: KNN, SVM, Decision trees, Naïve Bayes, Binary classification, multi class classification, clustering.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | DEEP LEARNING: CONVOLUTIONAL NEURAL NETWORKS                                                                                                                                                                                                                                                                                                                                                                                                           |   |   |   | 9      |
| Feed forward networks, Activation functions, back propagation in CNN, optimizers, batch normalization, convolution layers, pooling layers, fully connected layers, dropout, Examples of CNNs.                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | DEEP LEARNING: RNNs, AUTOENCODERS AND GANS                                                                                                                                                                                                                                                                                                                                                                                                             |   |   |   | 9      |
| State, Structure of RNN Cell, LSTM and GRU, Time distributed layers, Generating Text, Autoencoders: Convolutional Autoencoders, Denoising autoencoders, Variational autoencoders, GANs: The discriminator, generator, DCGANs                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| Total: 45 periods                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| REFERENCES:                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| 1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | J. S. R. Jang, C. T. Sun, E. Mizutani, Neuro Fuzzy and Soft Computing - A Computational Approach to Learning and Machine Intelligence, 2012. PHI learning                                                                                                                                                                                                                                                                                              |   |   |   |        |

|    |                                                                                                                   |
|----|-------------------------------------------------------------------------------------------------------------------|
| 2. | Deep Learning, Ian Good fellow, YoshuaBengio and Aaron Courville, MIT Press, ISBN:9780262035613, 2016.            |
| 3. | The Elements of Statistical Learning. Trevor Hastie, Robert Tibshirani and Jerome Friedman. Second Edition. 2009. |
| 4. | Pattern Recognition and Machine Learning. Christopher Bishop. Springer. 2006.                                     |
| 5. | Understanding Machine Learning. Shai Shalev-Shwartz and Shai Ben-David. Cambridge University Press. 2017.         |

| <b>COURSE OUTCOMES:</b><br>At the end of the course the student will be able to |                                                                                                                                                    | <b>BT Mapped<br/>(Highest Level)</b> |
|---------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|
| CO1:                                                                            | Illustrate the categorization of machine learning algorithms.                                                                                      | K2                                   |
| CO2:                                                                            | Compare and contrast the types of neural network architectures, activation functions                                                               | K2                                   |
| CO3:                                                                            | Acquaint with the pattern association using neural networks                                                                                        | K2                                   |
| CO4:                                                                            | Elaborate various terminologies related with pattern recognition and architectures of convolutional neural networks                                | K4                                   |
| CO5:                                                                            | Construct different feature selection and classification techniques and advanced neural network architectures such as RNN, Autoencoders, and GANs. | K2                                   |



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|                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                         |   |   |   |        |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|--------|
| POE2406                                                                                                                                                                                                                                                                                                       | IoT FOR SMART SYSTEMS                                                                                                                                                                                                                                                                                                                                                                                                                   |   |   |   |        |
|                                                                                                                                                                                                                                                                                                               | Category                                                                                                                                                                                                                                                                                                                                                                                                                                | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                               | OEC                                                                                                                                                                                                                                                                                                                                                                                                                                     | 3 | 0 | 0 | 3      |
| Course objectives                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                         |   |   |   |        |
|                                                                                                                                                                                                                                                                                                               | <ul style="list-style-type: none"><li>To study about Internet of Things technologies and its role in real time applications.</li><li>To introduce the infrastructure required for IoT</li><li>To familiarize the accessories and communication techniques for IoT.</li><li>To provide insight about the embedded processor and sensors required for IoT</li><li>To familiarize the different platforms and Attributes for IoT</li></ul> |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                                                                      | INTRODUCTION TO INTERNET OF THINGS                                                                                                                                                                                                                                                                                                                                                                                                      |   |   |   |        |
| Overview, Hardware and software requirements for IOT, Sensor and actuators, Technology drivers, Business drivers, Typical IoT applications, Trends and implications.                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                         |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                                                                     | IOT ARCHITECTURE                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| IoT reference model and architecture -Node Structure - Sensing, Processing, Communication, Powering, Networking - Topologies, Layer/Stack architecture, IoT standards, Cloud computing for IoT, Bluetooth, Bluetooth Low Energy beacons.                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                         |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                                                                    | PROTOCOLS AND WIRELESS TECHNOLOGIES FOR IOT                                                                                                                                                                                                                                                                                                                                                                                             |   |   |   |        |
| <b>PROTOCOLS:</b><br>NFC, SCADA and RFID, Zigbee    MIPI, M-PHY, UniPro, SPMI, SPI, M-PCIe    GSM, CDMA, LTE, GPRS, small cell.<br><b>Wireless technologies for IoT:</b> WiFi (IEEE 802.11), Bluetooth/Bluetooth Smart, ZigBee/ZigBee Smart, UWB (IEEE 802.15.4), 6LoWPAN, Proprietary systems-Recent trends. |                                                                                                                                                                                                                                                                                                                                                                                                                                         |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                                                                     | IOT PROCESSORS                                                                                                                                                                                                                                                                                                                                                                                                                          |   |   |   |        |
| <b>Services/Attributes:</b> Big-Data Analytics for IOT, Dependability,Interoperability, Security, Maintainability.<br><b>Embedded processors for IOT :</b> Introduction to Python programming -Building IOT with RASPERRY PI and Arduino.                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                         |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                                                                                      | CASE STUDIES                                                                                                                                                                                                                                                                                                                                                                                                                            |   |   |   |        |
| Industrial IoT, Home Automation, smart cities, Smart Grid, connected vehicles, electric vehicle charging, Environment, Agriculture, Productivity Applications, IOT Defense                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                         |   |   |   |        |
| Total: 45 periods                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                         |   |   |   |        |
| REFERENCES:                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                         |   |   |   |        |

|    |                                                                                                                                                                                            |
|----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. | ArshdeepBahga and VijaiMadiseti : A Hands-on Approach “Internet of Things”,Universities Press 2015.                                                                                        |
| 2. | Oliver Hersent , David Boswarthick and Omar Elloumi “ The Internet of Things”, Wiley,2016.                                                                                                 |
| 3. | Samuel Greengard, “ The Internet of Things”, The MIT press, 2015.                                                                                                                          |
| 4. | Adrian McEwen and Hakim Cassimally“Designing the Internet of Things “Wiley,2014.                                                                                                           |
| 5. | Jean- Philippe Vasseur, Adam Dunkels, “Interconnecting Smart Objects with IP: The Next Internet” Morgan Kuffmann Publishers, 2010.                                                         |
| 6. | Adrian McEwen and Hakim Cassimally, “Designing the Internet of Things”, John Wiley and sons, 2014.                                                                                         |
| 7. | Lingyang Song/DusitNiyato/ Zhu Han/ Ekram Hossain,” Wireless Device-to-Device Communications and Networks, CAMBRIDGE UNIVERSITY PRESS,2015.                                                |
| 8. | OvidiuVermesan and Peter Friess (Editors), “Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems”, River Publishers Series in Communication, 2013. |
| 9. | Vijay Madiseti , ArshdeepBahga, “Internet of Things (A Hands on-Approach)”, 2014.                                                                                                          |
| 10 | Zach Shelby, Carsten Bormann, “6LoWPAN: The Wireless Embedded Internet”, John Wileyand sons, 2009.                                                                                         |

#### **COURSE OUTCOMES:**

At the end of the course the student will be able to

**BT Mapped  
(Highest Level)**

|      |                                                                                |    |
|------|--------------------------------------------------------------------------------|----|
| CO1: | Analyze the concepts of IoT and its present developments.                      | K4 |
| CO2: | Compare and contrast different platforms and infrastructures available for IoT | K4 |
| CO3: | Explain different protocols and communication technologies used in IoT         | K2 |
| CO4: | Analyze the big data analytic and programming of IoT                           | K4 |
| CO5: | Implement IoT solutions for smart applications                                 | K6 |

#### **Mapping of COs with POs and PSOs**

| COs/POs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---------|-----|-----|-----|-----|-----|-----|
| CO1     | -   | 1   | 3   | -   | -   | -   |
| CO2     | -   | -   | 2   | -   | -   | -   |
| CO3     | -   | -   | 2   | 1   | -   | -   |
| CO4     | -   | -   | 3   | -   | -   | -   |
| CO5     | -   | -   | 2   | 1   | -   | -   |
| Avg.    | -   | 1   | 2   | 1   | -   | -   |

1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom’s Taxonomy

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |          |   |   |   |        |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|---|---|---|--------|
| POE2408                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | CLOUD COMPUTING TECHNOLOGIES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |          |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Category | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | OEC      | 3 | 0 | 0 | 3      |
| Course objectives                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |          |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <ul style="list-style-type: none"><li>· To gain expertise in Virtualization, Virtual Machines and deploy practical virtualization solution</li><li>· To understand the architecture, infrastructure and delivery models of cloud computing.</li><li>· To explore the roster of AWS services and illustrate the way to make applications in AWS</li><li>· To gain knowledge in the working of Windows Azure and Storage services offered by Windows Azure</li><li>· To develop the cloud application using various programming model of Hadoop and Aneka</li></ul> |          |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | VIRTUALIZATION AND VIRTUALIZATION INFRASTRUCTURE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |          |   |   |   | 6      |
| Basics of Virtual Machines - Process Virtual Machines – System Virtual Machines –Emulation – Interpretation – Binary Translation - Taxonomy of Virtual Machines. Virtualization –Management Virtualization — Hardware Maximization – Architectures – Virtualization Management – Storage Virtualization – Network Virtualization- Implementation levels of virtualization – virtualization structure – virtualization of CPU, Memory and I/O devices – virtual clusters and Resource Management – Virtualization for data center automation (WASH) and Integrated Water Resources Management (IWRM) - Need and Importance of WASH |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |          |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | CLOUD PLATFORM ARCHITECTURE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |          |   |   |   | 12     |
| Cloud Computing: Definition, Characteristics - Cloud deployment models: public, private, hybrid, community – Categories of cloud computing: Everything as a service: Infrastructure, platform, software- A Generic Cloud Architecture Design – Layered cloud Architectural Development Architectural Design Challenges                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |          |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | AWS CLOUD PLATFORM - IAAS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |          |   |   |   | 9      |
| Amazon Web Services: AWS Infrastructure- AWS API- AWS Management Console - Setting up AWS Storage - Stretching out with Elastic Compute Cloud - Elastic Container Service for Kubernetes- AWS Developer Tools: AWS Code Commit, AWS Code Build, AWS Code Deploy, AWS Code Pipeline, AWS code Star - AWS Management Tools: Cloud Watch, AWS Auto Scaling, AWS control Tower, Cloud Formation, Cloud Trail, AWS License Manager                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |          |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | PAAS CLOUD PLATFORM                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |          |   |   |   | 9      |
| Windows Azure: Origin of Windows Azure, Features, The Fabric Controller – First Cloud APP in Windows Azure- Service Model and Managing Services: Definition and Configuration, Service                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |          |   |   |   |        |

|                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                        |                          |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| runtime API- Windows Azure Developer Portal- Service Management API- Windows Azure Storage Characteristics-Storage Services- REST API- Blobs                                                                                                                                                                                                                              |                                                                                                                                                        |                          |
| <b>UNIT – V</b>                                                                                                                                                                                                                                                                                                                                                           | <b>PROGRAMMING MODEL</b>                                                                                                                               | <b>9</b>                 |
| Introduction to Hadoop Framework - Mapreduce, Input splitting, map and reduce functions, specifying input and output parameters, configuring and running a job –Developing Map Reduce Applications - Design of Hadoop file system –Setting up Hadoop Cluster- Aneka: Cloud Application Platform, Thread Programming, Task Programming and Map-Reduce Programming in Aneka |                                                                                                                                                        |                          |
|                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                        | <b>Total: 45 periods</b> |
| <b>REFERENCES:</b>                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                        |                          |
| 1.                                                                                                                                                                                                                                                                                                                                                                        | Bernard Golden, Amazon Web Service for Dummies, John Wiley & Sons, 2013.                                                                               |                          |
| 2.                                                                                                                                                                                                                                                                                                                                                                        | Raoul Alongi, AWS: The Most Complete Guide to Amazon Web Service from Beginner to Advanced Level, Amazon Asia- Pacific Holdings Private Limited, 2019. |                          |
| 3.                                                                                                                                                                                                                                                                                                                                                                        | Sriram Krishnan, Programming: Windows Azure, O'Reilly, 2010.                                                                                           |                          |
| 4.                                                                                                                                                                                                                                                                                                                                                                        | Rajkumar Buyya, Christian Vacchiola, S.Thamarai Selvi, Mastering Cloud Computing , McGraw Hill Education (India) Pvt. Ltd., 2013.                      |                          |
| 5.                                                                                                                                                                                                                                                                                                                                                                        | Danielle Ruest, Nelson Ruest, —Virtualization: A Beginner"s Guide II , McGraw-Hill Osborne Media, 2009.                                                |                          |

| <b>COURSE OUTCOMES:</b>                                   |                                                                                  | <b>BT Mapped (Highest Level)</b> |
|-----------------------------------------------------------|----------------------------------------------------------------------------------|----------------------------------|
| On completion of the course, the students will be able to |                                                                                  |                                  |
| CO1:                                                      | Employ the concepts of virtualization in the cloud computing                     | K3                               |
| CO2:                                                      | Identify the architecture, infrastructure and delivery models of cloud computing | K2                               |
| CO3:                                                      | Develop the Cloud Application in AWS platform                                    | K6                               |
| CO4:                                                      | Apply the concepts of Windows Azure to design Cloud Application                  | K3                               |
| CO5:                                                      | Develop services using various Cloud computing programming models.               | K6                               |

  
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|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|--------|
| POE2409                                                                                                                                                                                                                                                                                                                                                                                                              | PRINCIPLES OF MULTIMEDIA |                                                                                                                                                                                                                                                                                                                                                                                                     |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                      |                          | Category                                                                                                                                                                                                                                                                                                                                                                                            | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                                                                                                                                      |                          | OEC                                                                                                                                                                                                                                                                                                                                                                                                 | 3 | 0 | 0 | 3      |
| Course objectives                                                                                                                                                                                                                                                                                                                                                                                                    |                          |                                                                                                                                                                                                                                                                                                                                                                                                     |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                      |                          | <ul style="list-style-type: none"><li>• To get familiarity with gamut of multimedia and its significance</li><li>• To acquire knowledge in multimedia components.</li><li>• To acquire knowledge about multimedia tools and authoring.</li><li>• To acquire knowledge in the development of multimedia applications</li><li>• To explore the latest trends and technologies in multimedia</li></ul> |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                                                                                                                                                                             | INTRODUCTION             |                                                                                                                                                                                                                                                                                                                                                                                                     |   |   |   | 6      |
| Introduction to Multimedia – Characteristics of Multimedia Presentation – Multimedia Components– Promotion of Multimedia Based Components – Digital Representation – Media and Data Streams – Multimedia Architecture – Multimedia Documents, Multimedia Tasks and Concerns, Production, sharing and distribution, Hypermedia, WWW and Internet, Authoring, Multimedia over wireless and mobile networks.            |                          |                                                                                                                                                                                                                                                                                                                                                                                                     |   |   |   |        |
| Suggested Activities:                                                                                                                                                                                                                                                                                                                                                                                                |                          |                                                                                                                                                                                                                                                                                                                                                                                                     |   |   |   |        |
| 1. Flipped classroom on media Components.                                                                                                                                                                                                                                                                                                                                                                            |                          |                                                                                                                                                                                                                                                                                                                                                                                                     |   |   |   |        |
| 2. External learning – Interactive presentation.                                                                                                                                                                                                                                                                                                                                                                     |                          |                                                                                                                                                                                                                                                                                                                                                                                                     |   |   |   |        |
| Suggested Evaluation Methods:                                                                                                                                                                                                                                                                                                                                                                                        |                          |                                                                                                                                                                                                                                                                                                                                                                                                     |   |   |   |        |
| 1. Tutorial – Handling media components                                                                                                                                                                                                                                                                                                                                                                              |                          |                                                                                                                                                                                                                                                                                                                                                                                                     |   |   |   |        |
| 2. Quizzes on different types of data presentation.                                                                                                                                                                                                                                                                                                                                                                  |                          |                                                                                                                                                                                                                                                                                                                                                                                                     |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                                                                                                                                                                            | ELEMENTS OF MULTIMEDIA   |                                                                                                                                                                                                                                                                                                                                                                                                     |   |   |   | 12     |
| Text-Types, Font, Unicode Standard, File Formats, Graphics and Image data representations –data types, file formats, color models; video – color models in video, analog video, digital video, file formats, video display interfaces, 3D video and TV: Audio – Digitization, SNR, SQNR, quantization, audio quality, file formats, MIDI; Animation- Key Frames and Tweening, other Techniques, 2D and 3D Animation. |                          |                                                                                                                                                                                                                                                                                                                                                                                                     |   |   |   |        |
| Suggested Activities:                                                                                                                                                                                                                                                                                                                                                                                                |                          |                                                                                                                                                                                                                                                                                                                                                                                                     |   |   |   |        |
| 1. Flipped classroom on different file formats of various media elements.                                                                                                                                                                                                                                                                                                                                            |                          |                                                                                                                                                                                                                                                                                                                                                                                                     |   |   |   |        |
| 2. External learning – Adobe after effects, Adobe Media Encoder, Adobe Audition.                                                                                                                                                                                                                                                                                                                                     |                          |                                                                                                                                                                                                                                                                                                                                                                                                     |   |   |   |        |
| Suggested Evaluation Methods:                                                                                                                                                                                                                                                                                                                                                                                        |                          |                                                                                                                                                                                                                                                                                                                                                                                                     |   |   |   |        |
| 1. Demonstration on after effects animations.                                                                                                                                                                                                                                                                                                                                                                        |                          |                                                                                                                                                                                                                                                                                                                                                                                                     |   |   |   |        |
| 2. Quizzes on file formats and color models.                                                                                                                                                                                                                                                                                                                                                                         |                          |                                                                                                                                                                                                                                                                                                                                                                                                     |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                                                                                                                                                                           | MULTIMEDIA TOOLS         |                                                                                                                                                                                                                                                                                                                                                                                                     |   |   |   | 9      |
| Authoring Tools – Features and Types – Card and Page Based Tools – Icon and Object Based Tools –                                                                                                                                                                                                                                                                                                                     |                          |                                                                                                                                                                                                                                                                                                                                                                                                     |   |   |   |        |

Time Based Tools – Cross Platform Authoring Tools – Editing Tools – Painting and Drawing Tools – 3D Modeling and Animation Tools – Image Editing Tools – Sound Editing Tools – Digital Movie Tools.

**Suggested Activities:**

1. Flipped classroom on multimedia tools.
2. External learning – Comparison of various authoring tools.

**Suggested Evaluation Methods:**

1. Tutorial – Audio editing tool.
2. Quizzes on animation tools.

**UNIT – IV**

**MULTIMEDIA SYSTEMS**

**9**

Compression Types and Techniques: CODEC, Text Compression: GIF Coding Standards, JPEG standard – JPEG 2000, basic audio compression – ADPCM, MPEG Psychoacoustics, basic Video compression techniques – MPEG, H.26X – Multimedia Database System – User Interfaces – OS Multimedia Support – Hardware Support – Real Time Protocols – Play Back Architectures – Synchronization – Document Architecture – Hypermedia Concepts: Hypermedia Design – Digital Copyrights, Content analysis.

**Suggested Activities:**

1. Flipped classroom on concepts of multimedia hardware architectures.
2. External learning – Digital repositories and hypermedia design.

**Suggested Evaluation Methods:**

1. Quizzes on multimedia hardware and compression techniques.
2. Tutorial – Hypermedia design.

**UNIT – V**

**MULTIMEDIA APPLICATIONS FOR THE WEB AND MOBILE PLATFORMS**

**9**

ADDIE Model – Conceptualization – Content Collection – Storyboard–Script Authoring Metaphors – Testing – Report Writing – Documentation. Multimedia for the web and mobile platforms. Virtual Reality, Internet multimedia content distribution, Multimedia Information sharing – social media sharing, cloud computing for multimedia services, interactive cloud gaming. Multimedia information retrieval.

**Suggested Activities:**

1. External learning – Game consoles.
2. External learning – VRML scripting languages.

**Suggested Evaluation Methods:**

1. Demonstration of simple interactive games.
2. Tutorial – Simple VRML program.

**Total: 45 periods**

**REFERENCES:**

1. Li, Ze-Nian, Drew, Mark, Liu, Jiangchuan, "Fundamentals of Multimedia", Springer, Third Edition, 2021.
2. Prabhat K. Andleigh, Kiran Thakrar, "MULTIMEDIA SYSTEMS DESIGN", Pearson Education, 2015.

|    |                                                                                                         |
|----|---------------------------------------------------------------------------------------------------------|
| 3. | Gerald Friedland, Ramesh Jain, "Multimedia Computing", Cambridge University Press, 2018. (digital book) |
| 4. | Ranjan Parekh, "Principles of Multimedia", Second Edition, McGraw-Hill Education, 2017                  |

| <b>COURSE OUTCOMES:</b><br>On completion of the course, the students will be able to |                                                                                           | <b>BT Mapped<br/>(Highest Level)</b> |
|--------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|--------------------------------------|
| CO1:                                                                                 | Handle the multimedia elements effectively.                                               | K3                                   |
| CO2:                                                                                 | Articulate the concepts and techniques used in multimedia applications.                   | K3                                   |
| CO3:                                                                                 | Develop effective strategies to deliver Quality of Experience in multimedia applications. | K6                                   |
| CO4:                                                                                 | Design and implement algorithms and techniques applied to multimedia objects.             | K5                                   |
| CO5:                                                                                 | Design and develop multimedia applications following software engineering models.         | K6                                   |



|                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                             |          |   |   |   |        |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|---|---|---|--------|
| POE2413                                                                                                                                                                                                                                                                                                                                                                                                                                                | SUSTAINABLE MANAGEMENT                                                                                                                                                                                                                                                                                                                                      |          |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                             | Category | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                             | OEC      | 3 | 0 | 0 | 3      |
| Course objectives                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                             |          |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <ul style="list-style-type: none"><li>· To provide students with fundamental knowledge of the notion of corporate sustainability.</li><li>· To determine how organizations impacts on the environment and socio-technical systems, the relationship between social and environmental performance and competitiveness, the approaches and methods.</li></ul> |          |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                                                                                                                                                                                                               | MANAGEMENT OF SUSTAINABILITY                                                                                                                                                                                                                                                                                                                                |          |   |   |   | 9      |
| Management of sustainability -rationale and political trends: An introduction to sustainability management, International and European policies on sustainable development, theoretical pillars in sustainability management studies.                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                             |          |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                                                                                                                                                                                                              | CORPORATE SUSTAINABILITY AND RESPONSIBILITY                                                                                                                                                                                                                                                                                                                 |          |   |   |   | 9      |
| Corporate sustainability parameter, corporate sustainability institutional framework, integration of sustainability into strategic planning and regular business practices, fundamentals of stakeholder engagement.                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                             |          |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                                                                                                                                                                                                             | SUSTAINABILITY MANAGEMENT: STRATEGIES AND APPROACHES                                                                                                                                                                                                                                                                                                        |          |   |   |   | 9      |
| Corporate sustainability management and competitiveness: Sustainability-oriented corporate strategies, markets and competitiveness, Green Management between theory and practice, Sustainable Consumption and Green Marketing strategies, Environmental regulation and strategic postures; Green Management approaches and tools; Green engineering: clean technologies and innovation processes; Sustainable Supply Chain Management and Procurement. |                                                                                                                                                                                                                                                                                                                                                             |          |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                                                                                                                              | SUSTAINABILITY AND INNOVATION                                                                                                                                                                                                                                                                                                                               |          |   |   |   | 9      |
| Socio-technical transitions and sustainability, Sustainable entrepreneurship, Sustainable pioneers in green market niches, Smart communities and smart specializations.                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                             |          |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                                                                                                                                                                                                                               | SUSTAINABLE MANAGEMENT OF RESOURCES, COMMODITIES AND COMMONS                                                                                                                                                                                                                                                                                                |          |   |   |   | 9      |
| Energy management, Water management, Waste management, Wild Life Conservation, Emerging trends in sustainable management, Case Studies.                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                             |          |   |   |   |        |
| Total: 45 periods                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                             |          |   |   |   |        |
| REFERENCES:                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                             |          |   |   |   |        |
| 1.                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Daddi, T., Iraldo, F., Testa, Environmental Certification for Organizations and Products: Management. 2015                                                                                                                                                                                                                                                  |          |   |   |   |        |

|    |                                                                                                           |
|----|-----------------------------------------------------------------------------------------------------------|
| 2. | Christian N. Madu, Handbook of Sustainability Management 2012                                             |
| 3. | Petra Molthan-Hill, The Business Student's Guide to Sustainable Management: Principles and Practice, 2014 |
| 4. | Margaret Robertson, Sustainability Principles and Practice, 2014                                          |
| 5. | Peter Rogers, An Introduction to Sustainable Development, 2006                                            |

| <b>COURSE OUTCOMES:</b><br>Upon completion of this course, the students will be able to: |                                                                                                                                                                    | <b>BT Mapped<br/>(Highest Level)</b> |
|------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|
| CO1:                                                                                     | An understanding of sustainability management as an approach to aid in evaluating and minimizing environmental impacts while achieving the expected social impact. | K2                                   |
| CO2:                                                                                     | An understanding of corporate sustainability and responsible Business Practices                                                                                    | K2                                   |
| CO3:                                                                                     | Knowledge and skills to understand, to measure and interpret sustainability performances. landscape system.                                                        | K2                                   |
| CO4:                                                                                     | Knowledge of innovative practices in sustainable business and community management                                                                                 | K2                                   |
| CO5:                                                                                     | Deep understanding of sustainable management of resources and commodities                                                                                          | K2                                   |

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|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|--------|
| POE2414                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | MICRO AND SMALL BUSINESS MANAGEMENT                                                                                                                                                                                          |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Category                                                                                                                                                                                                                     | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | OEC                                                                                                                                                                                                                          | 3 | 0 | 0 | 3      |
| Course objectives                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                              |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <ul style="list-style-type: none"><li>To familiarize students with the theory and practice of small business management.</li><li>To learn the legal issues faced by small business and how they impact operations.</li></ul> |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | INTRODUCTION TO SMALL BUSINESS                                                                                                                                                                                               |   |   |   | 9      |
| Creation, Innovation, entrepreneurship and small business - Defining Small Business –Role of Owner – Manager – government policy towards small business sector –elements of entrepreneurship –evolution of entrepreneurship –Types of Entrepreneurship – social, civic, corporate - Business life cycle - barriers and triggers to new venture creation – process to assist start ups – small business and family business.                                                                                                                        |                                                                                                                                                                                                                              |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | SCREENING THE BUSINESS OPPORTUNITY AND FORMULATING THE BUSINESS PLAN                                                                                                                                                         |   |   |   | 9      |
| Concepts of opportunity recognition; Key factors leading to new venture failure; New venture screening process; Applying new venture screening process to the early stage small firm Role planning in small business – importance of strategy formulation – management skills for small business creation and development.                                                                                                                                                                                                                         |                                                                                                                                                                                                                              |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | BUILDING THE RIGHT TEAM AND MARKETING STRATEGY                                                                                                                                                                               |   |   |   | 9      |
| Management and Leadership – employee assessments – Tuckman’s stages of group development The entrepreneurial process model - Delegation and team building - Comparison of HR management in small and large firms - Importance of coaching and how to apply a coaching model.Marketing within the small business - success strategies for small business marketing - customer delight and business generating systems, - market research, - assessing market performance- sales management and strategy - the marketing mix and marketing strategy. |                                                                                                                                                                                                                              |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | FINANCING SMALL BUSINESS                                                                                                                                                                                                     |   |   |   | 9      |
| Main sources of entrepreneurial capital; Nature of ‘bootstrap’ financing - Difference between cash and profit - Nature of bank financing and equity financing - Funding-equity gap for small firms. Importance of working capital cycle - Calculation of break-even point - Power of gross profit margin- Pricing for profit - Credit policy issues and relating these to cash flow management and profitability.                                                                                                                                  |                                                                                                                                                                                                                              |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | VALUING SMALL BUSINESS AND CRISIS MANAGEMENT                                                                                                                                                                                 |   |   |   | 9      |
| Causes of small business failure - Danger signals of impending trouble - Characteristics of poorly performing firms - Turnaround strategies - Concept of business valuation - Different valuation measurements - Nature of goodwill and how to measure it - Advantages and disadvantages of buying an established small firm - Process of preparing a business for sale.                                                                                                                                                                           |                                                                                                                                                                                                                              |   |   |   |        |
| Total: 45 periods                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                              |   |   |   |        |

**REFERENCES:**

|    |                                                                                                                                                                                                                              |
|----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. | Hankinson,A.(2000). "The key factors in the profile of small firm owner-managers that influence business performance. The South Coast Small Firms Survey, 1997-2000." <i>Industrial and Commercial Training</i> 32(3):94-98. |
| 2. | Parker,R.(2000). "Small is not necessarily beautiful: An evaluation of policy support for small and medium-sized enterprise in Australia." <i>Australian Journal of Political Science</i> 35(2):239-253.                     |
| 3. | Journal articles on SME's.                                                                                                                                                                                                   |

**COURSE OUTCOMES:**

Upon completion of this course, the students will be able to:

**BT Mapped  
(Highest Level)**

|      |                                                                                                  |    |
|------|--------------------------------------------------------------------------------------------------|----|
| CO1: | Familiarise the students with the concept of small business                                      | K2 |
| CO2: | In depth knowledge on small business opportunities and challenges                                | K2 |
| CO3: | Ability to devise plans for small business by building the right skills and marketing strategies | K2 |
| CO4: | Identify the funding source for small start ups                                                  | K4 |
| CO5: | Business evaluation for buying and selling of small firms                                        | K2 |

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| POE2415                                                                                                                                                                                                                                                             | INTELLECTUAL PROPERTY RIGHTS                                                                                                 |   |   |   |        |
|                                                                                                                                                                                                                                                                     | Category                                                                                                                     | L | T | P | Credit |
|                                                                                                                                                                                                                                                                     | OEC                                                                                                                          | 3 | 0 | 0 | 3      |
| Course objectives                                                                                                                                                                                                                                                   |                                                                                                                              |   |   |   |        |
|                                                                                                                                                                                                                                                                     | <ul style="list-style-type: none"><li>To understand intellectual property rights and its valuation.</li></ul>                |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                            | INTRODUCTION                                                                                                                 |   |   |   | 9      |
| Intellectual property rights - Introduction, Basic concepts, Patents, Copyrights, Trademarks, Trade Secrets, Geographic Indicators; Nature of Intellectual Property, Technological Research, Inventions and Innovations, History - the way from WTO to WIPO, TRIPS. |                                                                                                                              |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                           | PROCESS                                                                                                                      |   |   |   | 9      |
| New Developments in IPR, Procedure for grant of Patents, TM, GIs, Patenting under Patent Cooperation Treaty, Administration of Patent system in India, Patenting in foreign countries.                                                                              |                                                                                                                              |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                          | STATUTES                                                                                                                     |   |   |   | 9      |
| International Treaties and conventions on IPRs, The TRIPs Agreement, PCT Agreement, The Patent Act of India, Patent Amendment Act (2005), Design Act, Trademark Act, Geographical Indication Act, Bayh- Dole Act and Issues of Academic Entrepreneurship.           |                                                                                                                              |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                           | STRATEGIES IN INTELLECTUAL PROPERTY                                                                                          |   |   |   | 9      |
| Strategies for investing in R&D, Patent Information and databases, IPR strength in India, Traditional Knowledge, Case studies.                                                                                                                                      |                                                                                                                              |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                                            | MODELS                                                                                                                       |   |   |   | 9      |
| The technologies Know-how, concept of ownership, Significance of IP in Value Creation, IPValuation and IP Valuation Models, Application of Real Option Model in Strategic Decision Making, Transfer and Licensing.                                                  |                                                                                                                              |   |   |   |        |
| Total: 45 periods                                                                                                                                                                                                                                                   |                                                                                                                              |   |   |   |        |
| REFERENCES:                                                                                                                                                                                                                                                         |                                                                                                                              |   |   |   |        |
| 1.                                                                                                                                                                                                                                                                  | V. Sople Vinod, Managing Intellectual Property by (Prentice hall of India Pvt.Ltd), 2006.                                    |   |   |   |        |
| 2.                                                                                                                                                                                                                                                                  | Primer, R. Anita Rao and Bhanoji Rao, Intellectual Property Rights, Lastain Book company.                                    |   |   |   |        |
| 3.                                                                                                                                                                                                                                                                  | Edited by Derek Bosworth and Elizabeth Webster, The Management of Intellectual Property, Edward Elgar Publishing Ltd., 2006. |   |   |   |        |

| <b>COURSE OUTCOMES:</b> |                                                                                   | <b>BT Mapped (Highest Level)</b> |
|-------------------------|-----------------------------------------------------------------------------------|----------------------------------|
| CO1:                    | Understanding of intellectual property and appreciation of the need to protect it | K2                               |
| CO2:                    | Awareness about the process of patenting                                          | K2                               |
| CO3:                    | Understanding of the statutes related to IPR                                      | K2                               |
| CO4:                    | Ability to apply strategies to protect intellectual property                      | K4                               |
| CO5:                    | Ability to apply models for making strategic decisions related to IPR             | K2                               |

|                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                        |          |   |   |   |                              |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|---|---|---|------------------------------|
| POE2416                                                                                                                                                                                                                                                                                                                                                                                                      | ETHICAL MANAGEMENT                                                                                                                                                     |          |   |   |   |                              |
|                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                        | Category | L | T | P | Credit                       |
|                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                        | OEC      | 3 | 0 | 0 | 3                            |
| Course objectives                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                        |          |   |   |   |                              |
|                                                                                                                                                                                                                                                                                                                                                                                                              | <ul style="list-style-type: none"><li>To help students develop knowledge and competence in ethical management and decisionmaking in organizational contexts.</li></ul> |          |   |   |   |                              |
| UNIT – I                                                                                                                                                                                                                                                                                                                                                                                                     | ETHICS AND SOCIETY                                                                                                                                                     |          |   |   |   | 9                            |
| Ethical Management- Definition, Motivation, Advantages-Practical implications of ethical management. Managerial ethics, professional ethics, and social Responsibility-Role of culture and society's expectations- Individual and organizational responsibility to society and the community                                                                                                                 |                                                                                                                                                                        |          |   |   |   |                              |
| UNIT – II                                                                                                                                                                                                                                                                                                                                                                                                    | ETHICAL DECISION MAKING AND MANAGEMENT IN A CRISIS                                                                                                                     |          |   |   |   | 9                            |
| Managing in an ethical crisis, the nature of a crisis, ethics in crisis management, discuss case studies, analyze real-world scenarios, develop ethical management skills, knowledge, and competencies. Proactive crisis management.                                                                                                                                                                         |                                                                                                                                                                        |          |   |   |   |                              |
| UNIT – III                                                                                                                                                                                                                                                                                                                                                                                                   | STAKEHOLDERS IN ETHICAL MANAGEMENT                                                                                                                                     |          |   |   |   | 9                            |
| Stakeholders in ethical management, identifying internal and external stakeholders, nature of stakeholders, ethical management of various kinds of stakeholders: customers (product and service issues), employees (leadership, fairness, justice, diversity) suppliers, collaborators, business, community, the natural environment (the sustainability imperative, green management, Contemporary issues). |                                                                                                                                                                        |          |   |   |   |                              |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                                                                                    | INDIVIDUAL VARIABLES IN ETHICAL MANJAGEMENT                                                                                                                            |          |   |   |   | 9                            |
| Understanding individual variables in ethics, managerial ethics, concepts in ethical psychology- ethical awareness, ethical courage, ethical judgment, ethical foundations, ethical emotions/intuitions/intensity. Utilization of these concepts and competencies for ethical decision- making and management.                                                                                               |                                                                                                                                                                        |          |   |   |   |                              |
| UNIT – V                                                                                                                                                                                                                                                                                                                                                                                                     | PRACTICAL FIELD-GUIDE, TECHNIQUES AND SKILLS                                                                                                                           |          |   |   |   | 9                            |
| Ethical management in practice, development of techniques and skills, navigating challenges and dilemmas, resolving issues and preventing unethical management proactively. Role modelling and creating a culture of ethical management and human flourishing.                                                                                                                                               |                                                                                                                                                                        |          |   |   |   |                              |
| Total: 45 periods                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                        |          |   |   |   |                              |
| REFERENCES:                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                        |          |   |   |   |                              |
| 1.                                                                                                                                                                                                                                                                                                                                                                                                           | Brad Agle, Aaron Miller, Bill O` Rourke, The Business Ethics Field Guide: the essential companion to leading your career and your company, 2016.                       |          |   |   |   |                              |
| 2.                                                                                                                                                                                                                                                                                                                                                                                                           | Steiner & Steiner, Business, Government & Society: A managerial Perspective, 2011.                                                                                     |          |   |   |   |                              |
| 3.                                                                                                                                                                                                                                                                                                                                                                                                           | Lawrence & Weber, Business and Society: Stakeholders, Ethics, Public Policy, 2020.                                                                                     |          |   |   |   |                              |
| COURSE OUTCOMES:                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                        |          |   |   |   | BT Mapped<br>(Highest Level) |

|      |                                                                                   |    |
|------|-----------------------------------------------------------------------------------|----|
| CO1: | Role modelling and influencing the ethical and cultural context.                  | K2 |
| CO2: | Respond to ethical crises and proactively address potential crises situations.    | K2 |
| CO3: | Understand and implement stakeholder management decisions.                        | K2 |
| CO4: | Develop the ability, knowledge, and skills for ethical management.                | K4 |
| CO5: | Develop practical skills to navigate, resolve and thrive in management situations | K2 |

|                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                         |   |   |   |        |
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| POE2417                                                                                                                                                                                                                                                                                                                                                         | INTEGRATED WATER RESOURCES MANAGEMENT                                                                                                                                                                                                                                   |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                 | Category                                                                                                                                                                                                                                                                | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                                                                                 | PCC                                                                                                                                                                                                                                                                     | 3 | 0 | 0 | 3      |
| Course objectives                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                         |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                 | <ul style="list-style-type: none"><li>Students will be introduced to the concepts and principles of IWRM, which is inclusive of the economics, public-private partnership, water &amp; health, water &amp; food security and legal &amp; regulatory settings.</li></ul> |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                                                                                                                        | CONTEXT FOR IWRM                                                                                                                                                                                                                                                        |   |   |   | 9      |
| Water as a global issue: key challenges – Definition of IWRM within the broader context of development – Key elements of IWRM - Principles – Paradigm shift in water management - Complexity of the IWRM process – UN World Water Assessment - SDGs.                                                                                                            |                                                                                                                                                                                                                                                                         |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                                                                                                                       | WATER ECONOMICS                                                                                                                                                                                                                                                         |   |   |   | 9      |
| Economic view of water issues: economic characteristics of water good and services – Non-market monetary valuation methods – Water economic instruments – Private sector involvement in water resources management: PPP objectives, PPP models, PPP processes, PPP experiences through case studies.                                                            |                                                                                                                                                                                                                                                                         |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                                                                                                                      | LEGAL AND REGULATORY SETTINGS                                                                                                                                                                                                                                           |   |   |   | 9      |
| Basic notion of law and governance: principles of international and national law in the area of water management - Understanding UN law on non-navigable uses of international water courses – International law for groundwater management – World Water Forums – Global Water Partnerships - Development of IWRM in line with legal and regulatory framework. |                                                                                                                                                                                                                                                                         |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                                       | WATER AND HEALTH WITHIN THE IWRM CONTEXT                                                                                                                                                                                                                                |   |   |   | 9      |
| Links between water and health: options to include water management interventions for health – Health protection and promotion in the context of IWRM – Global burden of Diseases - Health impact assessment of water resources development projects – Case studies.                                                                                            |                                                                                                                                                                                                                                                                         |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                                                                                                                                        | AGRICULTURE IN THE CONCEPT OF IWRM                                                                                                                                                                                                                                      |   |   |   | 9      |
| Water for food production: ‘blue’ versus ‘green’ water debate – Water foot print - Virtual water trade for achieving global water and food security — Irrigation efficiencies, irrigation methods - current water pricing policy– scope to relook pricing.                                                                                                      |                                                                                                                                                                                                                                                                         |   |   |   |        |
| Total: 45 periods                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                         |   |   |   |        |

|                    |                                                                                                                                                                                                                                                                               |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>REFERENCES:</b> |                                                                                                                                                                                                                                                                               |
| 1.                 | Cech Thomas V., Principles of water resources: history, development, management and policy. John Wiley and Sons Inc., New York. 2003.                                                                                                                                         |
| 2.                 | Mollinga .P. etal “ Integrated Water Resources Management”, Water in South Asia Volume I, Sage Publications, 2006.                                                                                                                                                            |
| 3.                 | Technical Advisory Committee, Integrated Water Resources management, Technical Advisory Committee Background Paper No: 4. Global water partnership, Stockholm, Sweden. 2002.                                                                                                  |
| 4.                 | Technical Advisory Committee, Dublin principles for water as reflected in comparative assessment of institutional and legal arrangements for Integrated Water Resources Management, Technical Advisory Committee Background paper No: 3. Global water partnership, Stockholm, |

|    |                                                                                                                                                                    |
|----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | Sweden. 1999.                                                                                                                                                      |
| 5. | Technical Advisory Committee, Effective Water Governance". Technical Advisory Committee Background paper No: 7. Global water partnership, Stockholm, Sweden, 2003. |

| <b>COURSE OUTCOMES:</b><br>On completion of the course, the students will be able to |                                                                                                                   | <b>BT Mapped<br/>(Highest Level)</b> |
|--------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|--------------------------------------|
| CO1:                                                                                 | Describe the context and principles of IWRM; Compare the conventional and integrated ways of water management.    | K2                                   |
| CO2:                                                                                 | Select the best economic option among the alternatives; illustrate the pros and cons of PPP through case studies. | K4                                   |
| CO3:                                                                                 | Apply law and governance in the context of IWRM.                                                                  | K3                                   |
| CO4:                                                                                 | Discuss the linkages between water-health; develop a HIA framework.                                               | K6                                   |
| CO5:                                                                                 | Analyse how the virtual water concept pave way to alternate policy options.                                       | K4                                   |

| <b>Mapping of COs with POs and PSOs</b>                           |     |     |     |     |     |     |
|-------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|
| COs/POs                                                           | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
| CO1                                                               | -   | -   | 1   | 2   | -   | 3   |
| CO2                                                               | 1   | -   | 2   | 1   | -   | 2   |
| CO3                                                               | 2   | -   | 1   | 2   | 1   | 3   |
| CO4                                                               | -   | -   | 1   | 2   | 1   | 2   |
| CO5                                                               | 1   | -   | 1   | 2   | 3   | 3   |
| Avg.                                                              | 1   | -   | 1   | 2   | 1   | 3   |
| 1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy |     |     |     |     |     |     |

  
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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                |   |   |   |        |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|--------|
| POE2418                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | WATER, SANITATION AND HEALTH                                                                                                                                                                                                                   |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Category                                                                                                                                                                                                                                       | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | OE                                                                                                                                                                                                                                             | 3 | 0 | 0 | 3      |
| Course objectives                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <ul style="list-style-type: none"><li>Understand the accelerating health impacts due to the present managerial aspects and initiatives in water and sanitation and health sectors in the developing scenario</li></ul>                         |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | FUNDAMENTALS WASH                                                                                                                                                                                                                              |   |   |   | 9      |
| Meanings and Definition: Safe Water- Health, Nexus: Water- Sanitation - Health and Hygiene – Equity issues-Water security - Food Security. Sanitation And Hygiene (WASH) and Integrated Water Resources Management (IWRM) - Need and Importance of WASH                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | MANAGERIAL IMPLICATIONS AND IMPACT                                                                                                                                                                                                             |   |   |   | 9      |
| Third World Scenario – Poor and Multidimensional Deprivation--Health Burden in Developing Scenario -Factors contribute to water, sanitation and hygiene related diseases-Social: Social Stratification and Literacy Demography: Population and Migration- Fertility - Mortality- Environment: Water Borne-Water Washed and Water Based Diseases - Economic: Wage - Water and Health Budgeting -Psychological: Non-compliance - Disease Relapse - Political: Political Will |                                                                                                                                                                                                                                                |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | CHALLENGES IN MANAGEMENT AND DEVELOPMENT                                                                                                                                                                                                       |   |   |   | 9      |
| Common Challenges in WASH - Bureaucracy and Users- Water Utilities -Sectoral Allocation:- Infrastructure- Service Delivery: Health services: Macro and Micro- level: Community and Gender Issues- Equity Issues - Paradigm Shift: Democratization of Reforms and Initiatives.                                                                                                                                                                                              |                                                                                                                                                                                                                                                |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | GOVERNANCE                                                                                                                                                                                                                                     |   |   |   | 9      |
| Public health -Community Health Assessment and Improvement Planning (CHA/CHIP)- Infrastructure and Investments on Water, (WASH) - Cost Benefit Analysis – Institutional Intervention-Public Private Partnership - Policy Directives - Social Insurance -Political Will vs Participatory Governance -                                                                                                                                                                       |                                                                                                                                                                                                                                                |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | INITIATIVES                                                                                                                                                                                                                                    |   |   |   | 9      |
| Management vs Development -Accelerating Development- Development Indicators -Inclusive Development-Global and Local- Millennium Development Goal (MDG) and Targets - Five Year Plans - Implementation - Capacity Building - Case studies on WASH.                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                |   |   |   |        |
| Total: 45 periods                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                |   |   |   |        |
| REFERENCES:                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                |   |   |   |        |
| 1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Bonitha R., Beaglehole R., Kjellstorm, 2006, “Basic Epidemiology”, 2 <sup>nd</sup> Edition, World Health Organization                                                                                                                          |   |   |   |        |
| 2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Van Note Chism, N. and Bickford, D. J. (2002), Improving the environment for learning: An expanded agenda. New Directions for Teaching and Learning, 2002: 91–98. doi: 10.1002/tl.83Improving the Environment for learning: An Expanded Agenda |   |   |   |        |
| 3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | National Research Council. <i>Global Issues in Water, Sanitation, and Health: Workshop Summary</i> .                                                                                                                                           |   |   |   |        |

|    |                                                                                                                                         |
|----|-----------------------------------------------------------------------------------------------------------------------------------------|
|    | Washington, DC: The National Academies Press, 2009.                                                                                     |
| 4. | Sen, Amartya 1997. On Economic Inequality. Enlarged edition, with annex by James Foster and Amartya Sen, Oxford: Clarendon Press, 1997. |
| 5. | Inter sectoral Water Allocation Planning and Management, 2000, World Bank Publishers www. Amazon.com                                    |

| <b>COURSE OUTCOMES:</b><br>On completion of the course, the students will be able to |                                                                                                                                                              | <b>BT Mapped<br/>(Highest Level)</b> |
|--------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|
| CO1:                                                                                 | Capture to fundamental concepts and terms which are to be applied and understood all through the study.                                                      | K4                                   |
| CO2:                                                                                 | Comprehend the various factors affecting water sanitation and health through the lens of third world scenario.                                               | K2                                   |
| CO3:                                                                                 | Critically analyse and articulate the underlying common challenges in water, sanitation and health.                                                          | K4                                   |
| CO4:                                                                                 | Acquire knowledge on the attributes of governance and its say on water sanitation and health                                                                 | K2                                   |
| CO5:                                                                                 | Gain an overarching insight in to the aspects of sustainable resource management in the absence of a clear level playing field in the developmental aspects. | K2                                   |

**Mapping of COs with POs and PSOs**

| COs/POs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---------|-----|-----|-----|-----|-----|-----|
| CO1     | -   | -   | 1   | 2   | -   | 3   |
| CO2     | 1   | -   | 2   | 1   | -   | 2   |
| CO3     | 2   | -   | 1   | 2   | 1   | 3   |
| CO4     | -   | -   | 1   | 2   | 1   | 2   |
| CO5     | 1   | -   | 1   | 2   | 3   | 3   |
| Avg.    | 1   | -   | 1   | 2   | 1   | 3   |

1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom's Taxonomy

  
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| POE2420                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                      | BLOCK CHAIN TECHNOLOGIES                                                                                                                                                                                                                                                                                                                                                  |   |   |   |        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|--------|
|                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                      | Category                                                                                                                                                                                                                                                                                                                                                                  | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                      | OEC                                                                                                                                                                                                                                                                                                                                                                       | 3 | 0 | 0 | 3      |
| Course objectives                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                           |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                      | <ul style="list-style-type: none"><li>• This course is intended to study the basics of Block chain technology.</li><li>• During this course the learner will explore various aspects of Block chain technology like application in various domains.</li><li>• By implementing, learners will have idea about private and public Block chain, and smartcontract.</li></ul> |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                      | INTRODUCTION OF CRYPTOGRAPHY AND BLOCKCHAIN                                                                                                                                                                                                                                                                                                                               |   |   |   | 9      |
| Introduction to Block chain, Block chain Technology Mechanisms & Networks, Block chain Origins, Objective of Block chain, Block chain Challenges, Transactions and Blocks, P2P Systems, Keys as Identity, Digital Signatures, Hashing, and public key cryptosystems, private vs. public Block chain.                                                             |                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                           |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                      | BITCOIN AND CRYPTOCURRENCY                                                                                                                                                                                                                                                                                                                                                |   |   |   | 9      |
| Introduction to Bit coin, The Bit coin Network, The Bit coin Mining Process, Mining Developments, Bit coin Wallets, Decentralization and Hard Forks, Ethereum Virtual Machine (EVM), Merkle Tree, Double-Spend Problem, Block chain and Digital Currency, Transactional Blocks, Impact of Block chain Technology on Crypto currency.                             |                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                           |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                      | INTRODUCTION TO ETHEREUM                                                                                                                                                                                                                                                                                                                                                  |   |   |   | 9      |
| Introduction to Ethereum, Consensus Mechanisms, Metamask Setup, Ethereum Accounts, Transactions, Receiving Ethers, Smart Contracts.                                                                                                                                                                                                                              |                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                           |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                      | INTRODUCTION TO HYPERLEDGER AND SOLIDITY PROGRAMMING                                                                                                                                                                                                                                                                                                                      |   |   |   | 10     |
| Introduction to Hyper ledger, Distributed Ledger Technology & its Challenges, Hyper ledger & Distributed Ledger Technology, Hyper ledger Fabric, Hyper ledger Composer. Solidity - Language of Smart Contracts, Installing Solidity & Ethereum Wallet, Basics of Solidity, Layout of a Solidity Source File & Structure of Smart Contracts, General Value Types. |                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                           |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                      | BLOCKCHAIN APPLICATIONS                                                                                                                                                                                                                                                                                                                                                   |   |   |   | 8      |
| Internet of Things, Medical Record Management System, Domain Name Service and Future of Block chain, Alt Coins. Coding of Speech Signals, Quadrature Mirror Filters, Over Sampling A/D and D/A Conversion.                                                                                                                                                       |                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                           |   |   |   |        |
| Total: 45 periods                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                           |   |   |   |        |
| REFERENCES:                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                           |   |   |   |        |
| 1.                                                                                                                                                                                                                                                                                                                                                               | Imran Bashir, “Mastering Block chain: Distributed Ledger Technology, Decentralization, and Smart Contracts Explained”, Second Edition, Packt Publishing, 2018.       |                                                                                                                                                                                                                                                                                                                                                                           |   |   |   |        |
| 2.                                                                                                                                                                                                                                                                                                                                                               | Narayanan, J. Bonneau, E. Felten, A. Miller, S. Goldfeder, “Bitcoin and Crypto currency Technologies: A Comprehensive Introduction” Princeton University Press, 2016 |                                                                                                                                                                                                                                                                                                                                                                           |   |   |   |        |

|    |                                                                                                                |
|----|----------------------------------------------------------------------------------------------------------------|
| 3. | Antonopoulos, Mastering Bit coin, O'Reilly Publishing, 2014.                                                   |
| 4. | Antonopoulos and G. Wood, "Mastering Ethereum: Building Smart Contracts and Dapps", O'Reilly Publishing, 2018. |
| 5. | D. Drescher, Block chain Basics. Apress, 2017.                                                                 |

| COURSE OUTCOMES:<br>After the completion of this course, student will be able to |                                                                         | BT Mapped<br>(Highest Level) |
|----------------------------------------------------------------------------------|-------------------------------------------------------------------------|------------------------------|
| CO1:                                                                             | Understand and explore the working of Block chain technology            | K2                           |
| CO2:                                                                             | Analyze the working of Smart Contracts                                  | K2                           |
| CO3:                                                                             | Understand and analyze the working of Hyper ledger                      | K2                           |
| CO4:                                                                             | Apply the learning of solidity to build de-centralized apps on Ethereum | K4                           |
| CO5:                                                                             | Develop applications on Block chain                                     | K2                           |

|                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |          |   |   |   |                          |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|---|---|---|--------------------------|
| POE2423                                                                                                                                                                                                                       | ENERGY CONSERVATION AND MANAGEMENT IN DOMESTIC SECTORS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |          |   |   |   |                          |
|                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Category | L | T | P | Credit                   |
|                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | OEC      | 3 | 0 | 0 | 3                        |
| <b>Course objectives</b>                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |          |   |   |   |                          |
|                                                                                                                                                                                                                               | 1. To learn the present energy scenario and the need for energy conservation.<br>2. To understand the different measures for energy conservation in utilities.<br>3. Acquaint students with principle theories, materials, and construction techniques to create energy efficient buildings.<br>4. To identify the energy demand and bridge the gap with suitable technology for sustainable habitat<br>5. To get familiar with the energy technology, current status of research and find the ways to optimize a system as per the user requirement |          |   |   |   |                          |
| <b>UNIT – I</b>                                                                                                                                                                                                               | <b>ENERGY SCENARIO</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |          |   |   |   | <b>9</b>                 |
| Primary energy resources - Sectorial energy consumption (domestic, industrial and other sectors), Energy pricing, Energy conservation and its importance, Energy Conservation Act-2001 and its features – Energy star rating. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |          |   |   |   |                          |
| <b>UNIT – II</b>                                                                                                                                                                                                              | <b>HEATING, VENTILLATION &amp; AIR CONDITIONING</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |          |   |   |   | <b>9</b>                 |
| Basics of Refrigeration and Air Conditioning – COP / EER / SEC Evaluation – SPV system design & optimization for Solar Refrigeration.                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |          |   |   |   |                          |
| <b>UNIT – III</b>                                                                                                                                                                                                             | <b>LIGHTING, COMPUTER, TV</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |          |   |   |   | <b>9</b>                 |
| Specification of Luminaries – Types – Efficacy – Selection & Application – Time Sensors – Occupancy Sensors – Energy conservation measures in computer – Television – Electronic devices.                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |          |   |   |   |                          |
| <b>UNIT – IV</b>                                                                                                                                                                                                              | <b>ENERGY EFFICIENT BUILDINGS</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |          |   |   |   | <b>9</b>                 |
| Conventional versus Energy efficient buildings – Landscape design – Envelope heat loss and heat gain – Passive cooling and heating – Renewable sources integration.                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |          |   |   |   |                          |
| <b>UNIT – V</b>                                                                                                                                                                                                               | <b>ENERGY STORAGE TECHNOLOGIES</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |          |   |   |   | <b>9</b>                 |
| Necessity & types of energy storage – Thermal energy storage – Battery energy storage, charging and discharging– Hydrogen energy storage & Super capacitors – energy density and safety issues – Applications.                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |          |   |   |   |                          |
|                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |          |   |   |   | <b>Total: 45 periods</b> |
| <b>REFERENCES:</b>                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |          |   |   |   |                          |
| 1.                                                                                                                                                                                                                            | Yogi Goswami, Frank Kreith, Energy Efficiency and Renewable energy Handbook, CRC Press, 2016                                                                                                                                                                                                                                                                                                                                                                                                                                                         |          |   |   |   |                          |
| 2.                                                                                                                                                                                                                            | ASHRAE Handbook 2020 – HVAC Systems & Equipment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |          |   |   |   |                          |
| 3.                                                                                                                                                                                                                            | Paolo Bertoldi, Andrea Ricci, Anibal de Almeida, Energy Efficiency in Household Appliances and Lighting, Conference proceedings, Springer, 2001                                                                                                                                                                                                                                                                                                                                                                                                      |          |   |   |   |                          |
| 4.                                                                                                                                                                                                                            | David A. Bainbridge, Ken Haggard, Kenneth L. Haggard, Passive Solar Architecture: Heating, Cooling, Ventilation, Daylighting, and More Using Natural Flows, Chelsea Green Publishing, 2011.                                                                                                                                                                                                                                                                                                                                                          |          |   |   |   |                          |

| <b>COURSE OUTCOMES:</b><br>Upon completion of this course, the students will be able to: |                                                                                        | <b>BT Mapped<br/>(Highest Level)</b> |
|------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|--------------------------------------|
| CO1:                                                                                     | Understand technical aspects of energy conservation scenario.                          | K2                                   |
| CO2:                                                                                     | Energy audit in any type for domestic buildings and suggest the conservation measures. | K4                                   |
| CO3:                                                                                     | Perform building load estimates and design the energy efficient landscape system.      | K4                                   |
| CO4:                                                                                     | Gain knowledge to utilize an appliance/device sustainably.                             | K2                                   |
| CO5:                                                                                     | Understand the status and current technological advancement in energy storage field.   | K2                                   |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                            |   |   |   |        |
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| POE2424                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | ADDITIVE MANUFACTURING                                                                                                                                                                                                                                                                                     |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Category                                                                                                                                                                                                                                                                                                   | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | OE                                                                                                                                                                                                                                                                                                         | 3 | 0 | 0 | 3      |
| Course objectives                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                            |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <ul style="list-style-type: none"><li>• This course is intended to study the basics of Additive Manufacturing.</li><li>• During this course the learner will explore various design aspects of Additive Manufacturing.</li><li>• By implementing, learners will deal with real time Case studies</li></ul> |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | INTRODUCTION                                                                                                                                                                                                                                                                                               |   |   |   | 9      |
| Need - Development - Rapid Prototyping Rapid Tooling – Rapid Manufacturing – Additive Manufacturing. AM Process Chain- Classification – Benefits.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                            |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | DESIGN FOR ADDITIVE MANUFACTURING                                                                                                                                                                                                                                                                          |   |   |   | 9      |
| CAD Model Preparation - Part Orientation and Support Structure Generation -Model Slicing - Tool Path Generation Customized Design and Fabrication - Case Studies.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                            |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | VAT POLYMERIZATION                                                                                                                                                                                                                                                                                         |   |   |   | 9      |
| Stereolithography Apparatus (SLA)- Materials -Process -Advantages Limitations- Applications. Digital Light Processing (DLP) - Materials – Process - Advantages - Applications. Multi Jet Modelling (MJM) - Principles - Process - Materials - Advantages and Limitations.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                            |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | MATERIAL EXTRUSION AND SHEET LAMINATION                                                                                                                                                                                                                                                                    |   |   |   | 9      |
| Fused Deposition Modeling (FDM)- Process-Materials - Applications and Limitations. Sheet Lamination Process: Laminated Object Manufacturing (LOM)- Basic Principle- Mechanism: Gluing or Adhesive Bonding – Thermal Bonding- Materials- Application and Limitation - Bio-Additive Manufacturing Computer Aided Tissue Engineering (CATE) – Case studies<br>Selective Laser Sintering (SLS): Process –Mechanism– Typical Materials and Application- Multi Jet Fusion - Basic Principle— Materials- Application and Limitation - Three Dimensional Printing - Materials -Process - Benefits and Limitations. Selective Laser Melting (SLM) and Electron Beam Melting (EBM): Materials – Process - Advantages and Applications. Beam Deposition Process: Laser Engineered Net Shaping (LENS)- Process -Material Delivery - Process Parameters - Materials - Benefits -Applications. |                                                                                                                                                                                                                                                                                                            |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | CASE STUDIES AND OPPORTUNITIES ADDITIVE MANUFACTURING PROCESSES                                                                                                                                                                                                                                            |   |   |   | 9      |
| Education and training - Automobile- pattern and mould - tooling - Building Printing-Bio Printing - medical implants -development of surgical tools Food Printing -Printing Electronics. Business                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                            |   |   |   |        |

**REFERENCES:**

1. Andreas Gebhardt and Jan-Steffen Hötter "Additive Manufacturing: 3D Printing for Prototyping and Manufacturing", Hanser publications, United States, 2015, ISBN: 978-1- 56990-582-1..
2. Ian Gibson, David W. Rosen and Brent Stucker "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", 2nd edition, Springer., United States, 2015, ISBN13: 978-1493921126.
3. Amit Bandyopadhyay and Susmita Bose, "Additive Manufacturing", 1st Edition, CRC Press., United States, 2015, ISBN-13: 978-1482223590
4. Andreas Gebhardt, "Understanding Additive Manufacturing: Rapid Prototyping, Rapid Manufacturing", Hanser Gardner Publication, Cincinnati., Ohio, 2011, ISBN :9783446425521.
5. Chua C.K., Leong K.F., and Lim C.S., "Rapid prototyping: Principles and applications", Third edition, World Scientific Publishers, 2010.

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|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|---|---|-------------------|--------|
| POE2425                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | ELECTRIC VEHICLE TECHNOLOGY                                                                                                                                       |          |   |   |                   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                   | Category | L | T | P                 | Credit |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                   | OEC      | 3 | 0 | 0                 | 3      |
| UNIT – I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | NEED FOR ELECTRIC VEHICLES                                                                                                                                        |          |   |   |                   | 9      |
| History and need for electric and hybrid vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies, comparison of diesel, petrol, electric and hybrid vehicles, limitations, technical challenges                                                                                                                                                                                                                                                  |                                                                                                                                                                   |          |   |   |                   |        |
| UNIT – II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | ELECTRIC VEHICLE ARCHITECHTURE                                                                                                                                    |          |   |   |                   | 9      |
| Electric vehicle types, layout and power delivery, performance – traction motor characteristics, tractive effort, transmission requirements, vehicle performance, energy consumption, Concepts of hybrid electric drive train, architecture of series and parallel hybrid electric drive train, merits and demerits, mild and full hybrids, plug-in hybrid electric vehicles and range extended hybrid electric vehicles, Fuel cell vehicles.                                                                            |                                                                                                                                                                   |          |   |   |                   |        |
| UNIT – III                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | ENERGY STORAGE                                                                                                                                                    |          |   |   |                   | 9      |
| Batteries – types – lead acid batteries, nickel based batteries, and lithium based batteries, electrochemical reactions, thermodynamic voltage, specific energy, specific power, energy efficiency, Battery modeling and equivalent circuit, battery charging and types, battery cooling, Ultra-capacitors, Flywheel technology, Hydrogen fuel cell, Thermal Management of the PEM fuel cell                                                                                                                             |                                                                                                                                                                   |          |   |   |                   |        |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | ELECTRIC DRIVES AND CONTROL                                                                                                                                       |          |   |   |                   | 9      |
| Types of electric motors – working principle of AC and DC motors, advantages and limitations, DC motor drives and control, Induction motor drives and control, PMSM and brushless DC motor - drives and control , AC and Switch reluctance motor drives and control – Drive system efficiency – Inverters – DC and AC motor speed controllers                                                                                                                                                                            |                                                                                                                                                                   |          |   |   |                   |        |
| UNIT – V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | DESIGN OF ELECTRIC VEHICLES                                                                                                                                       |          |   |   |                   | 9      |
| Materials and types of production, Chassis skate board design, motor sizing, power pack sizing, component matching, Ideal gear box – Gear ratio, torque–speed characteristics, Dynamic equation of vehicle motion, Maximum tractive effort – Power train tractive effort Acceleration performance, rated vehicle velocity – maximum gradability, Brake performance, Electronic control system, safety and challenges in electric vehicles. Case study of Nissan leaf, Toyota Prius, tesla model 3, and Renault Zoe cars. |                                                                                                                                                                   |          |   |   |                   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                   |          |   |   | Total: 45 periods |        |
| REFERENCES:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                   |          |   |   |                   |        |
| 1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, 2 <sup>nd</sup> edition CRC Press, 2011.                                                        |          |   |   |                   |        |
| 2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004. |          |   |   |                   |        |
| 3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | James Larminie, John Lowry, Electric Vehicle Technology Explained - Wiley, 2003.                                                                                  |          |   |   |                   |        |
| 4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Ehsani, M, “Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design”, CRC Press, 2005                                            |          |   |   |                   |        |

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|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|--------|
| PAXC2401                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                           | CONSTITUTION OF INDIA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                           | Category                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                           | AC                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 2 | 0 | 0 | 0      |
| Course objectives                                                                                                                                                                                                                                                                                                                                                                               |                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                           | <ul style="list-style-type: none"><li>Understand the premises in forming the twin themes of liberty and freedom from a civil rights perspective.</li><li>To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional</li><li>Role and entitlement to civil and economic rights as well as the emergence nation hood in the early years of Indian nationalism.</li><li>To address the role of socialism in India after the commencement of the Bolshevik Revolution in1917and its impact on the initial drafting of the Indian Constitution</li></ul> |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                                                                                                                                                        | HISTORY OF MAKING OF THE INDIAN CONSTITUTION                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   | 5      |
| History, Drafting Committee,(Composition & Working)                                                                                                                                                                                                                                                                                                                                             |                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                                                                                                                                                       | PHILOSOPHY OF THE INDIAN CONSTITUTION                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   | 5      |
| Preamble, Salient Features                                                                                                                                                                                                                                                                                                                                                                      |                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                                                                                                                                                      | CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   | 5      |
| Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties                                                                                                                                                  |                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                                                                       | ORGANS OF GOVERNANCE                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   | 5      |
| Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions                                                                                                                                                                  |                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                                                                                                                                                                        | LOCAL ADMINISTRATION                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   | 5      |
| District's Administration head: Role and Importance, of Elected Representative, CEO, Municipal Corporation. Pachayatiraj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy. |                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| UNIT – VI                                                                                                                                                                                                                                                                                                                                                                                       | ELECTION COMMISSION                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   | 5      |
| Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners - Institute and Bodies for the welfare of SC/ST/OBC and women.                                                                                                                                                                                                                                |                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| Total: 30 periods                                                                                                                                                                                                                                                                                                                                                                               |                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| REFERENCES:                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| 1.                                                                                                                                                                                                                                                                                                                                                                                              | The Constitution of India,1950 (Bare Act),Government Publication                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |
| 2.                                                                                                                                                                                                                                                                                                                                                                                              | Dr.S.N.Busi, Dr.B.R. Ambedkar framing of Indian Constitution,1 <sup>st</sup> Edition,2015 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |   |   |        |

|    |                                                                             |
|----|-----------------------------------------------------------------------------|
| 3. | M.P.Jain, Indian Constitution Law, 7 <sup>th</sup> Edn., Lexis Nexis, 2014. |
| 4. | D.D.Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.     |

| COURSE OUTCOMES:<br>Students will be able to                      |                                                                                                                                                                                                                                                     | BT Mapped<br>(Highest Level) |     |     |     |     |
|-------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|-----|-----|-----|-----|
| CO1:                                                              | Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics                                                                                                                  | K2                           |     |     |     |     |
| CO2:                                                              | Discuss the intellectual origins of the frame work of argument that informed the conceptualization of social reforms leading to revolution in India                                                                                                 | K2                           |     |     |     |     |
| CO3:                                                              | Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution. | K2                           |     |     |     |     |
| CO4:                                                              | Discuss the passage of the Hindu Code Bill of 1956                                                                                                                                                                                                  | K2                           |     |     |     |     |
| Mapping of COs with POs and PSOs                                  |                                                                                                                                                                                                                                                     |                              |     |     |     |     |
| COs/POs                                                           | PO1                                                                                                                                                                                                                                                 | PO2                          | PO3 | PO4 | PO5 | PO6 |
| CO1                                                               | -                                                                                                                                                                                                                                                   | -                            | 2   | -   | 1   | -   |
| CO2                                                               | 1                                                                                                                                                                                                                                                   | -                            | -   | -   | 2   | -   |
| CO3                                                               | -                                                                                                                                                                                                                                                   | -                            | -   | 2   | -   | 2   |
| CO4                                                               | -                                                                                                                                                                                                                                                   | -                            | 3   | 1   | -   | -   |
| CO5                                                               | -                                                                                                                                                                                                                                                   | 2                            | -   | -   | 2   | -   |
| Avg.                                                              | 1                                                                                                                                                                                                                                                   | 2                            | 3   | 2   | 2   | 2   |
| 1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom’s Taxonomy |                                                                                                                                                                                                                                                     |                              |     |     |     |     |

| PAXC2402                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                | ENGLISH FOR RESEARCH PAPER WRITING     |     |     |     |                              |     |     |     |      |      |      |      |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|-----|-----|-----|------------------------------|-----|-----|-----|------|------|------|------|
|                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                | Category                               | L   | T   | P   | Credit                       |     |     |     |      |      |      |      |
|                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                | AC                                     | 2   | 0   | 0   | 0                            |     |     |     |      |      |      |      |
| Course objectives                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                |                                        |     |     |     |                              |     |     |     |      |      |      |      |
|                                                                                                                                                                                                                                                                   | <ul style="list-style-type: none"><li>• Teach how to improve writing skills and level of readability</li><li>• Tell about what to write in each section</li><li>• Summarize the skills needed when writing a Title</li><li>• Infer the skills needed when writing the Conclusion</li><li>• Ensure the quality of paper at very first-time submission</li></ul> |                                        |     |     |     |                              |     |     |     |      |      |      |      |
| UNIT – I                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                | INTRODUCTION TO RESEARCH PAPER WRITING |     |     |     |                              |     |     |     |      |      |      |      |
| Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness                                                                                   |                                                                                                                                                                                                                                                                                                                                                                |                                        |     |     |     |                              |     |     |     |      |      |      |      |
| UNIT – II                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                | PRESENTATION SKILLS                    |     |     |     |                              |     |     |     |      |      |      |      |
| Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                |                                        |     |     |     |                              |     |     |     |      |      |      |      |
| UNIT – III                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                | TITLE WRITING SKILLS                   |     |     |     |                              |     |     |     |      |      |      |      |
| Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check |                                                                                                                                                                                                                                                                                                                                                                |                                        |     |     |     |                              |     |     |     |      |      |      |      |
| UNIT – IV                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                | RESULT WRITING SKILLS                  |     |     |     |                              |     |     |     |      |      |      |      |
| Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions                                                                                 |                                                                                                                                                                                                                                                                                                                                                                |                                        |     |     |     |                              |     |     |     |      |      |      |      |
| UNIT – V                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                | VERIFICATION SKILLS                    |     |     |     |                              |     |     |     |      |      |      |      |
| Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first- time submission                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                |                                        |     |     |     |                              |     |     |     |      |      |      |      |
| Total: 45 periods                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                |                                        |     |     |     |                              |     |     |     |      |      |      |      |
| COURSE OUTCOMES:<br>On completion of the course, the students will be able to                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                |                                        |     |     |     | BT Mapped<br>(Highest Level) |     |     |     |      |      |      |      |
| CO1:                                                                                                                                                                                                                                                              | Understand that how to improve your writing skills and level of readability                                                                                                                                                                                                                                                                                    |                                        |     |     |     | K2                           |     |     |     |      |      |      |      |
| CO2:                                                                                                                                                                                                                                                              | Learn about what to write in each section                                                                                                                                                                                                                                                                                                                      |                                        |     |     |     | K2                           |     |     |     |      |      |      |      |
| CO3:                                                                                                                                                                                                                                                              | Understand the skills needed when writing a Title                                                                                                                                                                                                                                                                                                              |                                        |     |     |     | K2                           |     |     |     |      |      |      |      |
| CO4:                                                                                                                                                                                                                                                              | Understand the skills needed when writing the Conclusion                                                                                                                                                                                                                                                                                                       |                                        |     |     |     | K2                           |     |     |     |      |      |      |      |
| CO5:                                                                                                                                                                                                                                                              | Ensure the good quality of paper at very first-time submission                                                                                                                                                                                                                                                                                                 |                                        |     |     |     | K2                           |     |     |     |      |      |      |      |
| Mapping of COs with POs and PSOs                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                |                                        |     |     |     |                              |     |     |     |      |      |      |      |
| COs/POs                                                                                                                                                                                                                                                           | PO1                                                                                                                                                                                                                                                                                                                                                            | PO2                                    | PO3 | PO4 | PO5 | PO6                          | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 |
| CO1                                                                                                                                                                                                                                                               | -                                                                                                                                                                                                                                                                                                                                                              | 3                                      | -   | -   | -   | -                            | -   | -   | -   | -    | -    | -    | -    |
| CO2                                                                                                                                                                                                                                                               | -                                                                                                                                                                                                                                                                                                                                                              | 3                                      | -   | -   | -   | -                            | -   | -   | -   | -    | -    | -    | -    |
| CO3                                                                                                                                                                                                                                                               | -                                                                                                                                                                                                                                                                                                                                                              | 3                                      | -   | -   | -   | -                            | -   | -   | -   | -    | -    | -    | -    |
| CO4                                                                                                                                                                                                                                                               | -                                                                                                                                                                                                                                                                                                                                                              | 3                                      | -   | -   | -   | -                            | -   | -   | -   | -    | -    | -    | -    |
| CO5                                                                                                                                                                                                                                                               | -                                                                                                                                                                                                                                                                                                                                                              | 3                                      | -   | -   | -   | -                            | -   | -   | -   | -    | -    | -    | -    |
| Avg.                                                                                                                                                                                                                                                              | -                                                                                                                                                                                                                                                                                                                                                              | 3                                      | -   | -   | -   | -                            | -   | -   | -   | -    | -    | -    | -    |
| 1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom’s Taxonomy                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                |                                        |     |     |     |                              |     |     |     |      |      |      |      |



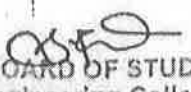
|    |                                                                                                                  |
|----|------------------------------------------------------------------------------------------------------------------|
|    | “NewRoyal book Company,2007.                                                                                     |
| 3. | Sahni, PardeepEt.Al. ,” Disaster Mitigation Experiences And Reflections”, Prentice Hall OfIndia, New Delhi,2001. |

| COURSE OUTCOMES:<br>Students will be able to                      |                                                                                                                                                            |     |     |     | BT Mapped<br>(Highest Level) |     |
|-------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|-----|------------------------------|-----|
| CO1:                                                              | Ability to summarize basics of disaster                                                                                                                    |     |     |     | K2                           |     |
| CO2:                                                              | Ability to explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.                                          |     |     |     | K2                           |     |
| CO3:                                                              | Ability to illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.                                    |     |     |     | K2                           |     |
| CO4:                                                              | Ability to describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations. |     |     |     | K2                           |     |
| Mapping of COs with POs and PSOs                                  |                                                                                                                                                            |     |     |     |                              |     |
| COs/POs                                                           | PO1                                                                                                                                                        | PO2 | PO3 | PO4 | PO5                          | PO6 |
| CO1                                                               | -                                                                                                                                                          | -   | -   | 1   | -                            | 1   |
| CO2                                                               | -                                                                                                                                                          | -   | 1   | 2   | -                            | 1   |
| CO3                                                               | -                                                                                                                                                          | -   | 1   | 2   | 1                            | -   |
| CO4                                                               | -                                                                                                                                                          | -   | 1   | 2   | 2                            | -   |
| CO5                                                               | -                                                                                                                                                          | -   | 1   | 2   | -                            | -   |
| Avg.                                                              | -                                                                                                                                                          | -   | 1   | 2   | 1                            | 1   |
| 1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom’s Taxonomy |                                                                                                                                                            |     |     |     |                              |     |

|                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                |   |   |   |        |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|--------|
| PAXCC2401                                                                                                                                                                                                                                                         | ENGLISH FOR RESEARCH PAPER WRITING                                                                                                                                                                                                                                                                                                                             |   |   |   |        |
|                                                                                                                                                                                                                                                                   | Category                                                                                                                                                                                                                                                                                                                                                       | L | T | P | Credit |
|                                                                                                                                                                                                                                                                   | AC                                                                                                                                                                                                                                                                                                                                                             | 2 | 0 | 0 | 0      |
| Course objectives                                                                                                                                                                                                                                                 | <ul style="list-style-type: none"><li>• Teach how to improve writing skills and level of readability</li><li>• Tell about what to write in each section</li><li>• Summarize the skills needed when writing a Title</li><li>• Infer the skills needed when writing the Conclusion</li><li>• Ensure the quality of paper at very first-time submission</li></ul> |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                          | INTRODUCTION TO RESEARCH PAPER WRITING                                                                                                                                                                                                                                                                                                                         |   |   |   | 6      |
| Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness.                                                                                  |                                                                                                                                                                                                                                                                                                                                                                |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                         | PRESENTATION SKILLS                                                                                                                                                                                                                                                                                                                                            |   |   |   | 6      |
| Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                        | TITLE WRITING SKILLS                                                                                                                                                                                                                                                                                                                                           |   |   |   | 6      |
| Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check |                                                                                                                                                                                                                                                                                                                                                                |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                         | RESULT WRITING SKILLS                                                                                                                                                                                                                                                                                                                                          |   |   |   | 6      |
| Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions                                                                                 |                                                                                                                                                                                                                                                                                                                                                                |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                                          | VERIFICATION SKILLS                                                                                                                                                                                                                                                                                                                                            |   |   |   | 6      |
| Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first- time submission                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                |   |   |   |        |
| Total: 30 periods                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                |   |   |   |        |
| TEXT BOOK:                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                |   |   |   |        |
| 1. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                |   |   |   |        |
| 2. Day R How to Write and Publish a Scientific Paper, Cambridge University Press 2006                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                |   |   |   |        |
| REFERENCES:                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                |   |   |   |        |
| 1. Goldbort R Writing for Science, Yale University Press (available on Google Books) 2006                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                |   |   |   |        |
| 2. Highman N, Handbook of Writing for the Mathematical Sciences, SIAM, Highman's book 1998.                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                |   |   |   |        |

  
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| COURSE OUTCOMES:<br>On completion of the course, the students will be able to |                                                                             |     |     |     |     |     |     |     |     |      |      | BT Mapped<br>(Highest Level) |      |      |  |
|-------------------------------------------------------------------------------|-----------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------------------------------|------|------|--|
| CO1:                                                                          | Understand that how to improve your writing skills and level of readability |     |     |     |     |     |     |     |     |      |      |                              | K1   |      |  |
| CO2:                                                                          | Learn about what to write in each section                                   |     |     |     |     |     |     |     |     |      |      |                              | K2   |      |  |
| CO3:                                                                          | Understand the skills needed when writing a Title                           |     |     |     |     |     |     |     |     |      |      |                              | K1   |      |  |
| CO4:                                                                          | Understand the skills needed when writing the Conclusion                    |     |     |     |     |     |     |     |     |      |      |                              | K1   |      |  |
| CO5:                                                                          | Ensure the good quality of paper at very first-time submission.             |     |     |     |     |     |     |     |     |      |      |                              | K1   |      |  |
| Mapping of COs with POs and PSOs                                              |                                                                             |     |     |     |     |     |     |     |     |      |      |                              |      |      |  |
| COs POs                                                                       | PO1                                                                         | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12                         | PSO1 | PSO2 |  |
| CO1                                                                           | 1                                                                           | 2   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -                            | -    | -    |  |
| CO2                                                                           | 1                                                                           | 2   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -                            | -    | -    |  |
| CO3                                                                           | 1                                                                           | 2   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -                            | -    | -    |  |
| CO4                                                                           | 1                                                                           | 2   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -                            | -    | -    |  |
| CO5                                                                           | 1                                                                           | 2   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -                            | -    | -    |  |
| Avg.                                                                          | 1                                                                           | 2   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -                            | -    | -    |  |
| 1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom's Taxonomy              |                                                                             |     |     |     |     |     |     |     |     |      |      |                              |      |      |  |

  
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|                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                      |   |   |   |        |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|--------|
| PAXCC2401                                                                                                                                                                                                                                                         | ENGLISH FOR RESEARCH PAPER WRITING                                                                                                                                                                                                                                                                                                                                   |   |   |   |        |
|                                                                                                                                                                                                                                                                   | Category                                                                                                                                                                                                                                                                                                                                                             | L | T | P | Credit |
|                                                                                                                                                                                                                                                                   | AC                                                                                                                                                                                                                                                                                                                                                                   | 2 | 0 | 0 | 0      |
| Course objectives                                                                                                                                                                                                                                                 | <ul style="list-style-type: none"> <li>• Teach how to improve writing skills and level of readability</li> <li>• Tell about what to write in each section</li> <li>• Summarize the skills needed when writing a Title</li> <li>• Infer the skills needed when writing the Conclusion</li> <li>• Ensure the quality of paper at very first-time submission</li> </ul> |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                          | INTRODUCTION TO RESEARCH PAPER WRITING                                                                                                                                                                                                                                                                                                                               |   |   |   | 6      |
| Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness.                                                                                  |                                                                                                                                                                                                                                                                                                                                                                      |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                         | PRESENTATION SKILLS                                                                                                                                                                                                                                                                                                                                                  |   |   |   | 6      |
| Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                      |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                        | TITLE WRITING SKILLS                                                                                                                                                                                                                                                                                                                                                 |   |   |   | 6      |
| Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check |                                                                                                                                                                                                                                                                                                                                                                      |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                         | RESULT WRITING SKILLS                                                                                                                                                                                                                                                                                                                                                |   |   |   | 6      |
| Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions                                                                                 |                                                                                                                                                                                                                                                                                                                                                                      |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                                          | VERIFICATION SKILLS                                                                                                                                                                                                                                                                                                                                                  |   |   |   | 6      |
| Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first- time submission                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                      |   |   |   |        |
| Total: 30 periods                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                      |   |   |   |        |
| TEXT BOOK:                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                      |   |   |   |        |
| 1. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                      |   |   |   |        |
| 2. Day R How to Write and Publish a Scientific Paper, Cambridge University Press 2006                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                      |   |   |   |        |
| REFERENCES:                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                      |   |   |   |        |
| 1. Goldbort R Writing for Science, Yale University Press (available on Google Books) 2006                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                      |   |   |   |        |
| 2. Highman N, Handbook of Writing for the Mathematical Sciences, SIAM, Highman's book 1998.                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                      |   |   |   |        |

  
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|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|--------|
| PAXCC2402                                                                                                                                                                                                                                                                                                                                           |  | DISASTER MANAGEMENT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                     |  | Category                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                                                                     |  | AC                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 2 | 0 | 0 | 0      |
| Course objectives                                                                                                                                                                                                                                                                                                                                   |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                     |  | <ul style="list-style-type: none"><li>• Summarize basics of disaster</li><li>• Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.</li><li>• Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.</li><li>• Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.</li><li>• Develop the strengths and weaknesses of disaster management approaches</li></ul> |   |   |   |        |
| UNIT - I                                                                                                                                                                                                                                                                                                                                            |  | INTRODUCTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |   |   |   |        |
| Disaster: Definition, Factors and Significance; Difference between Hazard And Disaster: Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.                                                                                                                                                                                     |  | 6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |   |   |   |        |
| UNIT - II                                                                                                                                                                                                                                                                                                                                           |  | REPERCUSSIONS OF DISASTERS AND HAZARDS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |   |   |   |        |
| Economic Damage, Loss of Human and Animal Life, Destruction Of Ecosystem, Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster, Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts. |  | 6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |   |   |   |        |
| UNIT - III                                                                                                                                                                                                                                                                                                                                          |  | DISASTER PRONE AREAS IN INDIA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |   |   |   |        |
| Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides And Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases and Epidemics                                                                                                                                          |  | 6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |   |   |   |        |
| UNIT - IV                                                                                                                                                                                                                                                                                                                                           |  | DISASTER PREPAREDNESS AND MANAGEMENT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |   |   |   |        |
| Preparedness: Monitoring Of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological And Other Agencies, Media Reports; Governmental and Community Preparedness.                                                                                                                      |  | 6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |   |   |   |        |
| UNIT - V                                                                                                                                                                                                                                                                                                                                            |  | RISK ASSESSMENT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |   |   |   |        |
| Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation, Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment, Strategies for Survival                                                                                    |  | 6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |   |   |   |        |
| REFERENCES:                                                                                                                                                                                                                                                                                                                                         |  | Total: 30 periods                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |   |   |   |        |
| 1. Goel S. L., Disaster Administration And Management Text And Case Studies", Deep & Deep Publication Pvt. Ltd., New Delhi, 2009                                                                                                                                                                                                                    |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |   |   |   |        |
| 2. Nishitha Rai, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "New Royal book Company, 2007.                                                                                                                                                                                                                        |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |   |   |   |        |
| 3. Sahni, Pardeep I.L.M. "Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi, 2001.                                                                                                                                                                                                                                |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |   |   |   |        |

  
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| COURSE OUTCOMES:<br>On completion of the course, the students will be able to |                                                                                                                                                            |     |     |     |     |     |     |     |     |      |      | BT Mapped<br>(Highest Level) |      |      |  |
|-------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------------------------------|------|------|--|
| CO1:                                                                          | Ability to summarize basics of disaster.                                                                                                                   |     |     |     |     |     |     |     |     |      |      |                              | K1   |      |  |
| CO2:                                                                          | Ability to explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.                                          |     |     |     |     |     |     |     |     |      |      |                              | K1   |      |  |
| CO3:                                                                          | Ability to illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.                                    |     |     |     |     |     |     |     |     |      |      |                              | K1   |      |  |
| CO4:                                                                          | Ability to describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations. |     |     |     |     |     |     |     |     |      |      |                              | K1   |      |  |
| CO5:                                                                          | Ability to develop the strengths and weaknesses of disaster management approaches.                                                                         |     |     |     |     |     |     |     |     |      |      |                              | K1   |      |  |
| Mapping of COs with POs and PSOs                                              |                                                                                                                                                            |     |     |     |     |     |     |     |     |      |      |                              |      |      |  |
| COs/POs                                                                       | PO1                                                                                                                                                        | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12                         | PSO1 | PSO2 |  |
| CO1                                                                           | 1                                                                                                                                                          | 2   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -                            | -    | -    |  |
| CO2                                                                           | 1                                                                                                                                                          | 2   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -                            | -    | -    |  |
| CO3                                                                           | 1                                                                                                                                                          | 2   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -                            | -    | -    |  |
| CO4                                                                           | 1                                                                                                                                                          | 2   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -                            | -    | -    |  |
| CO5                                                                           | 1                                                                                                                                                          | 2   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -                            | -    | -    |  |
| Avg.                                                                          | 1                                                                                                                                                          | 2   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -                            | -    | -    |  |
| 1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom's Taxonomy              |                                                                                                                                                            |     |     |     |     |     |     |     |     |      |      |                              |      |      |  |

  
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|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|--------|
| PAXCC2403                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                               | CONSTITUTION OF INDIA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |   |   |   |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                               | Category                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                               | AC                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 2 | 0 | 0 | 0      |
| Course objectives                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                               | <ul style="list-style-type: none"><li>Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.</li><li>To address the growth of Indian opinion regarding modern Indian intellectuals constitutional Role and entitlement to civil and economic rights as well as the emergence nation hood in the early years of Indian nationalism.</li><li>To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.</li></ul> |   |   |   |        |
| UNIT – I                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                               | HISTORY OF MAKING OF THE INDIAN CONSTITUTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |   |   |   |        |
| History, Drafting Committee, (Composition & Working)                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                               | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |   |   |   |        |
| UNIT – II                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                               | PHILOSOPHY OF THE INDIAN CONSTITUTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |   |   |   |        |
| Preamble, Salient Features                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                               | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |   |   |   |        |
| UNIT – III                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                               | CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |   |   |   |        |
| Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.                                                                                                                                                                                                  |                                                                                                                               | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |   |   |   |        |
| UNIT – IV                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                               | ORGANS OF GOVERNANCE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |   |   |   |        |
| Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.                                                                                                                                                                                                                  |                                                                                                                               | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |   |   |   |        |
| UNIT – V                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                               | LOCAL ADMINISTRATION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |   |   |   |        |
| District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO, Municipal Corporation, Panchayati raj: Introduction, PRI: Zila Panchayat, Elected officials and their roles, CEO Zila Panchayat: Position and role, Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy. |                                                                                                                               | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |   |   |   |        |
| UNIT – VI                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                               | ELECTION COMMISSION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |   |   |   |        |
| Election Commission: Role and Functioning, Chief Election Commissioner and Election Commissioners - Institute and Bodies for the welfare of SC/ST/OBC and women.                                                                                                                                                                                                                                                                                 |                                                                                                                               | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |   |   |   |        |
| REFERENCES:                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                               | Total: 30 periods                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |   |   |   |        |
| 1.                                                                                                                                                                                                                                                                                                                                                                                                                                               | Goel S. L., Disaster Administration And Management Text And Case Studies", Deep & Deep Publication Pvt. Ltd., New Delhi, 2009 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |   |   |   |        |
| 2.                                                                                                                                                                                                                                                                                                                                                                                                                                               | Nishintha Rai, Singh AK, "Disaster Management in India: Perspectives, issues and strategies" New Royal book Company, 2007     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |   |   |   |        |
| 3.                                                                                                                                                                                                                                                                                                                                                                                                                                               | Sahni, Pardeep LAL, "Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi, 2001.               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |   |   |   |        |

  
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| COURSE OUTCOMES:<br>On completion of the course, the students will be able to |                                                                                                                                                                                                                                                   |     |     |     |     |     |     |     |     |      |      | BT Mapped<br>(Highest Level) |      |      |
|-------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------------------------------|------|------|
| CO1:                                                                          | Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.                                                                                                               |     |     |     |     |     |     |     |     |      |      | K1                           |      |      |
| CO2:                                                                          | Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.                                                                                               |     |     |     |     |     |     |     |     |      |      | K1                           |      |      |
| CO3:                                                                          | Discuss the circumstances surrounding the foundation of the Congress Socialist Party[CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution |     |     |     |     |     |     |     |     |      |      | K1                           |      |      |
| CO4:                                                                          | Discuss the passage of the Governance.                                                                                                                                                                                                            |     |     |     |     |     |     |     |     |      |      | K1                           |      |      |
| CO5:                                                                          | Discuss the passage of the Local Administration.                                                                                                                                                                                                  |     |     |     |     |     |     |     |     |      |      | K1                           |      |      |
| CO6:                                                                          | Discuss the passage of the Hindu Code Bill of 1956.                                                                                                                                                                                               |     |     |     |     |     |     |     |     |      |      | K1                           |      |      |
| Mapping of COs with POs and PSOs                                              |                                                                                                                                                                                                                                                   |     |     |     |     |     |     |     |     |      |      |                              |      |      |
| COs/POs                                                                       | PO1                                                                                                                                                                                                                                               | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12                         | PSO1 | PSO2 |
| CO1                                                                           | 1                                                                                                                                                                                                                                                 | 2   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -                            | -    | -    |
| CO2                                                                           | 1                                                                                                                                                                                                                                                 | 2   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -                            | -    | -    |
| CO3                                                                           | 1                                                                                                                                                                                                                                                 | 2   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -                            | -    | -    |
| CO4                                                                           | 1                                                                                                                                                                                                                                                 | 2   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -                            | -    | -    |
| CO5                                                                           | 1                                                                                                                                                                                                                                                 | 2   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -                            | -    | -    |
| CO6                                                                           | 1                                                                                                                                                                                                                                                 | 2   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -                            | -    | -    |
| Avg.                                                                          | 1                                                                                                                                                                                                                                                 | 2   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -                            | -    | -    |
| 1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy             |                                                                                                                                                                                                                                                   |     |     |     |     |     |     |     |     |      |      |                              |      |      |

  
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|                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |   |   |   |        |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|--------|
| PAXCC2404                                                                                                                                                                                                                                                                            | நற்றமிழ் இலக்கியம்                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |   |   |   |        |
|                                                                                                                                                                                                                                                                                      | Category                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | L | T | P | Credit |
|                                                                                                                                                                                                                                                                                      | AC                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 2 | 0 | 0 | 0      |
| Course objectives                                                                                                                                                                                                                                                                    | <ul style="list-style-type: none"> <li>Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.</li> <li>To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional Role and entitlement to civil and economic rights as well as the emergence nation hood in the early years of Indian nationalism.</li> <li>To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.</li> </ul> |   |   |   |        |
| UNIT - I                                                                                                                                                                                                                                                                             | சங்க இலக்கியம்                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |   |   |   | 5      |
| <ol style="list-style-type: none"> <li>1. தமிழின் துவக்க நூல் தொல்காப்பியம்<br/>- எழுத்து, சொல், பொருள்</li> <li>2. அகநானூறு (82)<br/>- இயற்கை இன்னிசை அரங்கம்</li> <li>3. குறிஞ்சிப் பாட்டின் மலர்க்காட்சி</li> <li>4. புறநானூறு (95, 195)<br/>- போரை நிறுத்திய ஒளவையார்</li> </ol> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |   |   |   |        |
| UNIT - II                                                                                                                                                                                                                                                                            | அறநெறிதமிழ்                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |   |   |   | 5      |
| <ol style="list-style-type: none"> <li>1. அறநெறி வகுத்த திருவள்ளுவர்<br/>- அறம் வலியுறுத்தல், அன்புடைமை, ஒப்புரவறிதல், ஈகை, புகழ்</li> <li>2. பிற அறநூல்கள் - இலக்கிய மருந்து<br/>- ஏலாதி, சிறுபஞ்சமூலம், திரிகடுகம், ஆசாரக்கோவை (தூய்மையை வலியுறுத்தும் நூல்)</li> </ol>            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |   |   |   |        |
| UNIT - III                                                                                                                                                                                                                                                                           | இரட்டை காப்பியங்கள்                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |   |   |   | 5      |
| <ol style="list-style-type: none"> <li>1. கண்ணகியின் புரட்சி<br/>- சிலப்பதிகார வழக்குரை காதை</li> <li>2. சமூகசேவை இலக்கியம் மணிமேகலை<br/>- சிறைக்கோட்டம் அறக்கோட்டமாகிய காதை</li> </ol>                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |   |   |   |        |
| UNIT - IV                                                                                                                                                                                                                                                                            | அருள் நெறித்தமிழ்                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |   |   |   | 5      |

  
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1. சிறுபாணாற்றுப்படை

- பாரி முல்லைக்குத் தேர் கொடுத்தது. பேகன் மயிலுக்குப் போர்வை கொடுத்தது. அதியமான் ஓளவைக்கு நெல்லிக்கனி கொடுத்தது. அரசர் பண்புகள்

2. நற்றிணை

- அன்னைக்குரிய புன்னை சிறப்பு

3. திருமந்திரம் (617, 618)

- இயமம் நியமம் விதிகள்

4. தர்மச்சாலையை நிறுவிய வள்ளலார்

5. புறநானூறு

- சிறுவனே வள்ளலானான்

6. அகநானூறு (4) - வண்டு

UNIT - V

நவீன தமிழ் இலக்கியம்

5

1. உரைநடைத் தமிழ்,

- தமிழின் முதல் புதினம்,
- தமிழின் முதல் சிறுகதை,
- கட்டுரை இலக்கியம்,
- பயண இலக்கியம்,
- நாடகம்,

2. நாட்டு விடுதலை போராட்டமும் தமிழ் இலக்கியமும்,

3. சமுதாய விடுதலையும் தமிழ் இலக்கியமும்,

4. பெண் விடுதலையும் விளிம்பு நிலையினரின் மேம்பாட்டில் தமிழ் இலக்கியமும்.

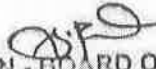
5. அறிவியல் தமிழ்.

6. இணையத்தில் தமிழ்,

7. சுற்றுச்சூழல் மேம்பாட்டில் தமிழ் இலக்கியம்.

Total: 30 periods

REFERENCES:

  
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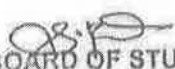
**தமிழ் இலக்கிய வெளியீடுகள் / புத்தகங்கள்**

1. தமிழ் இணைய கல்விக்கழகம் (Tamil Virtual University)  
- [www.tamilvu.org](http://www.tamilvu.org)
2. தமிழ் விக்கிப்பீடியா (Tamil Wikipedia)  
- <https://ta.wikipedia.org>
3. தர்மபுர ஆதீன வெளியீடு
4. வாழ்வியல் களஞ்சியம்  
- தமிழ்ப் பல்கலைக்கழகம், தஞ்சாவூர்
5. தமிழ்கலைக் களஞ்சியம்  
- தமிழ் வளர்ச்சித் துறை (thamilvalarchilthurai.com)
6. அறிவியல் களஞ்சியம்  
- தமிழ்ப் பல்கலைக்கழகம், தஞ்சாவூர்

**Mapping of COs with POs and PSOs**

| COs/POs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|
| CO1     | 1   | 2   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -    | -    | -    |
| CO2     | 1   | 2   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -    | -    | -    |
| CO3     | 1   | 2   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -    | -    | -    |
| CO4     | 1   | 2   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -    | -    | -    |
| CO5     | 1   | 2   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -    | -    | -    |
| CO6     | 1   | 2   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -    | -    | -    |
| Avg.    | 1   | 2   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -    | -    | -    |

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