DETAIL
COURSE CURRICULUM
FOR
POSTGRADUATE PROGRAMME
M.TECH
IN
ENVIRONMENTAL ENGINEERING

DEPARTMENT OF CIVIL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY AGARTALA

AGARTALA-799046

TRIPURA, INDIA

Preface

Civil Engineering Department of NIT Agartala, awards the degree of Master of Technology (M. Tech) in seven different specializations viz, Environmental Engineering, Geotechnical Engineering, Hydro-Informatics Engineering, Structural Engineering, Seismic Science and Engineering, Transportation Engineering and Water Resources Engineering.

The course structures of all post graduate degree programmes are carrying a total of 80 credits and 2000 marks. Semester wise distribution of course and credits are as follows: First semester: 25 credits and 800 marks for five theory subjects (comprises basic core, core, and elective subjects), two laboratory subjects and seminar; Second semester: 25 credits and 800 marks for four theory subject (comprises basic core, core, and elective subjects), two laboratory subjects, comprehensive viva-voce and project preliminaries; Third semester: 10 credits and 100 marks; and Fourth semester: 20 credits and 300 marks. Third and fourth semester of PG courses will be fully devoted to project works. Minimum requirement of number of class hours for each theory course is 40 hours per semester.

There will be continuous assessment of the performance of students throughout the semester. Each theory subject in a semester is evaluated for 100 marks, with the following weightages. Sub-component weightage: Continuous evaluation: 30 Marks (Attendance: 5 Marks, Quiz: 5 Marks, Class test: 10 Marks, Assignment: 10 Marks); Mid-semester Examination: 20 Marks; and End-semester Examination: 50 Marks

The course curriculum of M Tech Environmental Engineering programme is designed considering the following six Programme Outcomes (POs) and two Program Specific Objectives (PSO's).

List of PO's

PO1: An ability to independently carry out research /investigation and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/document.

PO3: 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

PO4: An ability to identify, formulate and solve Environmental Engineering related problems using advanced level computing techniques

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PO5: An ability to understand the impact of Environmental Engineering solutions in a global, economic, environmental and societal context

PO6: Ability to demonstrate the knowledge of environmental engineering and management principles and apply these to multidisciplinary environments.

List of PSO's

PSO1: Analysis, design, investigation of complex problems in ways which are sustainable and environmental friendly.

PSO2: Handling of any civil engineering projects ethically either as an individual or as a team.

Expert opinions are being taken in regular basis in order to improve the quality of teaching learning process and to attain the programme outcomes efficiently.

In the Final year of M.Tech programmes (Third and Fourth Semesters) students may also opt for industrial research. If any student desire to pursue his/her research in reputed industries, he/she may be allowed to do so, provided:

a. The selected industry is a permanent member of NASSCOM, FICCI and other such industry bodies.
b. The selected industry needs is approved by the DPPC of the concerned Department.
c. The student selects one supervisor from industry and another supervisor from the Institute.
d. If any student opts for such industrial research he/she will not receive any scholarship from the institute in this tenure, even if he/she wants to return back. In such cases the student will be allowed to complete his/her project in the institute but without any scholarship.

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CONTENT

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Syllabus: M.Tech Environmental Engineering

First Semester

Sl. No.	Subject	Credit	Class Hours per Week	Marks
1	**Basic Core** **PCE41C01**: Water and wastewater Treatment Processes-I	4	4	100
2	**Core Subject-I** **PCE41C02**: Applied Environmental Chemistry and Microbiology	4	4	100
3	**Core Subject-II** **PCE41C03:** Air and Noise Pollution & Control	4	4	100
4	**Elective Paper-I (PCE41E01)** **PCE41E01-01:** Optimization Technique **PCE41E01-02:** Advanced Mathematics **PCE41E01-03:** Computational fluid dynamics **PCE41E01-04:** Global warming and climate change	4	4	100
5	**Elective Paper-II (PCE41E02)** One course from Elective Group	4	4	100
6	**PCE41P01:** Water Pollution Laboratory-I	2	3	100
7	**PCE41P02:** Computer Laboratory	2	3	100
8	**PCE41P03:** Seminar	1	2	100
	Total	**25**	**28**	**800**

Second Semester

Sl. No.	Subject	Credit	Class Hours per Week	Marks
1	**Basic Core** **PCE42C01:** Water and wastewater Treatment Processes-II	4	4	100
2	**Core Subject-I** **PCE42C02:** Solid and Hazardous Waste Management	4	4	100
3	**Core Subject-II** **PCE42C03:** Ecology & Environmental Impact Assessment	4	4	100
4	**Elective Paper-III (PCE42E01)** One course from Elective Group (excluding the course already selected as Elective Paper-II)	4	4	100
5	**PCE42P01:** Water Pollution Laboratory-II	2	3	100
6	**PCE42P02:** Air Pollution Laboratory	2	3	100
7	**PCE42P03:** Comprehensive Viva-voice	2	0	100
8	**PCE42P04:** Project Preliminaries	3	6	100
	Total	**25**	**28**	**800**

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Third Semester

Sl. No.	Subject	Credit	Class Hours per Week	Marks
1	**PCE43P01:** Project and Thesis-I	**10**	-----	**100**

Fourth Semester

Sl. No.	Subject	Credit	Class Hours per Week	Marks
1	**PCE44P01:** Project and Thesis-II	**20**	-----	**300**

Total Credit (First to Fourth Semester): 80

Total Marks (First to Fourth Semester): 2000

Elective Pool

(Selected Electives will be offered in each semester based on available faculties)

Sl. No.	Subject	Credit	Class Hours per Week	Marks
1	Remote Sensing and GIS in Environmental Engineering	4	4	100
2	Hydraulics & Water Resources Engineering	4	4	100
3	Water Distribution and Wastewater Collection System Design	4	4	100
4	Air and Water Quality Modelling	4	4	100
5	Environmental Planning and Management	4	4	100
6	Industrial Pollution Control	4	4	100
7	Advanced Environmental Biotechnology	4	4	100
8	Management Of Water Resources	4	4	100
9	Renewable Energy System	4	4	100
10	Geo-environmental Engineering	4	4	100

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Syllabus for M.TECH (Environmental Engineering)

First Semester

Sl. No.	Subject	Credit	Class Hours per Week	Marks
1	**Basic Core** **PCE41C01**: Water and wastewater Treatment Processes-I	4	4	100
2	**Core Subject-I** **PCE41C02**: Applied Environmental Chemistry and Microbiology	4	4	100
3	**Core Subject-II** **PCE41C03:** Air and Noise Pollution & Control	4	4	100
4	**Elective Paper-I (PCE41E01)** **PCE41E01-01:** Optimization Technique **PCE41E01-02:** Advanced Mathematics **PCE41E01-03:** Computational fluid dynamics **PCE41E01-04:** Global warming and climate change	4	4	100
5	**Elective Paper-II (PCE41E02)** One course from Elective Group	4	4	100
6	**PCE41P01:** Water Pollution Laboratory-I	2	3	100
7	**PCE41P02:** Computer Laboratory	2	3	100
8	**PCE41P03:** Seminar	1	2	100
	Total	**25**	**28**	**800**

Basic Core

WATER AND WASTEWATER TREATMENT PROCESS-I (PCE41C01)

Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Course Objective

1. To make the students conversant with Water quality parameters and standards for various water uses.
2. To have adequate knowledge on sources of water.
3. To have adequate knowledge on various unit operations e.g, aeration tank, sedimentation tank, coagulation and filtration tank.
4. To have adequate knowledge on various unit processes e.g, disinfection, softening, fluoridation and de-fluoridation.
5. To understand bench Scale and Pilot Plant studies in water treatment.
6. To understand the basics of rural Water Supply Systems.

Course Content

Unit-1

Introduction – Sources of water, necessity of treatment, Critical Water quality parameters, water quality guidelines and standards for various water uses.

Unit-2

Unit operations – principles and design of aeration systems – two film theory, water in air system, air in water system. Intake structures – Different types, design criteria.

Unit-3

Principles of sedimentation – types of settling and settling equations, design criteria and design of settling tanks. Principle of Coagulation and Flocculation – types of coagulants, coagulants aids, coagulation theory, optimum dose of coagulant, design criteria and numerical examples.

Unit-4

Filtration – theory, types, hydraulics of filter bed, design criteria and design of filters, filter backwash, operational problems and trouble shooting.

Unit-5

Adsorption process – types, factors affecting adsorption, kinetics and equilibrium – different isotherm equations and their applications.

Unit-6

Unit processes – disinfection – different types, disinfectants, factors affecting disinfection, methods of disinfection, chemistry of chlorination.

Unit-7

Water Softening – Ions causing hardness, Langelier index, various methods.

Unit-8

Fluoridation and de-fluoridation – Principles and design.

Unit-9

Trace organic contaminants in water supplies and their removal. Bench Scale and Pilot plant studies in water treatment. Rural water supply systems

References:

1. Fair, G.M., Geyer J.C and Okun, (2010) "Water and Wastewater Engineering", 3rd Edition, Vol. II, John Wiley Publications.
2. Weber W.J., (1975) "Physico – Chemical Processes for Water Quality Control", John Wiley & Sons.
3. AWWA, (2011), "Water Quality and Treatment", 6th Edition, McGraw Hill.
4. CPHEEO Manual, (1999), "Water Supply and Treatment", GOI Publications.
5. Peavey, H.S., Rowe and Tchobonoglous,G., (2017), "Environmental Engineering", 1st Edition, McGraw Hill.
6. Raju, B.S.N., (1995), "Water Supply and Wastewater Engineering", Tata McGraw Hill Pvt. Co. Ltd., New Delhi.
7. World Health Organization, Geneva, (2004), Guidelines for Drinking Water Quality, Third Edition, Volumes 1-3.

Course Outcome

1. Students will be able to analyse the characteristics of water.
2. Students will be able to design intake structure for collection of water from various sources of water.
3. Students will be able to design aeration tank, sedimentation tank, coagulation and filtration tank.
4. Students will be able to design disinfection, softening, fluoridation and de-fluoridation unit.
5. Students will be able to analyse bench Scale and Pilot Plant studies in water treatment.
6. Students will be able to design various units of rural water system.

Table-1: To establish the correlation between COs & POs

No. of Curse Outcome (CO)	Course Outcome
PCE41C01.1	Students will be able to analyze characteristics of water.
PCE41C01.2	Students will be able to design intake structure for collection of water from various sources of water.
PCE41C01.3	Students will be able to design aeration tank, sedimentation tank, coagulation and filtration tank.
PCE41C01.4	Students will be able to design disinfection, softening, fluoridation and de-fluoridation unit.
PCE41C01.5	Students will be able to analyze bench Scale and Pilot Plant studies in water treatment.
PCE41C01.6	Students will be able to design various units of rural water system.

Table-2: Correlation between COs & POs

Slight (LOW): 1 Moderate (MEDIUM): 2 Substantial (HIGH): 3 and

for NO CORELATION: '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE41C01.1	3	2	3	3	3	3
PCE41C01.2	3	2	3	2	3	2
PCE41C01.3	3	2	3	3	2	3
PCE41C01.4	3	2	3	2	2	3
PCE41C01.5	3	2	3	3	3	2
PCE41C01.6	3	2	3	3	3	3
Total	**18**	**12**	**18**	**16**	**16**	**16**
Average	**3**	**2**	**3**	**2.67**	**2.67**	**2.67**
Equivalent Avg. Attainment	**3**	**2**	**3**	**3**	**3**	**3**

Table 3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE51E04.1	3	3
PCE51E04.2	3	3
PCE51E04.3	3	3
PCE51E04.4	3	3
PCE51E04.5	3	3
PCE51E04.6	3	3
Total	18	18
Average	3	3
Equivalent Avg. Attainment	**3**	**3**

Core Subject-I

APPLIED ENVIRONMENTAL CHEMISTRY AND MICROBIOLOGY (PCE41C02)

Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses Objective:

1. To make the students conversant with fundamentals of Environmental chemistry
2. To have adequate knowledge on environmental interactions and measurement of water and wastewater quality parameters
3. To have adequate knowledge on various principles and applications of colloidal chemistry and colorimetry
4. To have adequate knowledge on various unit processes e.g, titrimetry, gravimetry, Solvent extraction, chromatography, gas chromatography, HPLC, GC-MS, atomic absorption spectroscopy.
5. To understand the importance of Microorganisms in air, water and soil environment.
6. To familiarize the students with Microbiological Parameter Analysis, measurement techniques and applications in environmental engineering.

Course Content:

Unit-1

Importance of Environmental Chemistry, Types of reactions, redox reactions, reaction kinetics, Electrochemistry and its applications.

Unit-2

Physical and equilibrium chemistry – fundamentals and applications. Trace Contaminants and their analyses, Gibbs energy, chemical potential, chemical equilibrium, acid base reaction

Unit-3

pH – Principle, Measurement, Numerical Examples, Buffers and Buffer index, pE-pH diagram, Acidity, Alkalinity, Langelier index, Solubility diagram, Oxidation and Reduction equilibrium.

Unit-4

Colloidal Chemistry – Properties of colloids, colloidal dispersions, stability of colloids and applications. Preparation and purification of colloidal systems: Kinetic properties: The motion of particles in liquid media; Brownian motion and translational diffusion, Molecular

Thermodynamics of Hydrogen-Bonded Systems, Thermally Sensitive Particles: Preparation, Characterization, and Application

Unit-5

Colorimetry – Principles and applications, Lambert's law, Beer's law, Instruments of Colorimetry: Colorimeter, Spectrophotometer, Light, Vision and Photometry, Definition of Photometric Quantities, Photometric Units, Calculation of Colorimetric Values.

Unit-6

Applications of Analytical Chemistry – emission and absorption techniques, titrimetric, gravimetry, Solvent extraction, chromatography, gas chromatography, HPLC, GC-MS, atomic absorption spectroscopy, ICP-AES, flame photometry, electrophoresis, X-ray fluorescence, X-ray diffraction,

Unit-7

Adsorption – physical versus chemical adsorption, factors influencing adsorption, Adsorption isotherms, Design of adsorption column

Unit-8

Microbiology – Microorganisms of importance in air, water and soil environment Principles and applications of microscopy, microscopic flora and fauna of importance, Microorganisms – Classification, prokaryotic and eukaryotic cells, structure, characteristics, nucleic acids, DNA and RNA, Viruses, their detection and quantification

Unit-9

Metabolism and metabolic pathways, Bioconcentration, Biomagnification and Bioaccumulation, Bio-sphere, earth energy budget, Ecosystem, Uniformitarianism, Metabolic classification of microorganisms: phototrophs, chemotrophs, applications in environmental engineering

Unit-10

Bacteria – Morphology, typical growth curve and generation time, Measurement Techniques – APC, MPN (Probability and Thomas methods), coliforms - faecal coliforms - E.coli, Streptococcus faecalis differentiation of coliforms - significance - MPN index, M.F. technique, standards, Microbiological Parameter Analysis, Measurements and Isolation of Microorganism, Enzymes – classification, kinetics – Michaelis-Menten equation, factors influencing enzyme reaction.

References:

1. Tchobanoglous G., Burton F., and Stensel H.D., (2017), "Water and Wastewater Treatment Processes", 4th Edition, Metcalf & Eddy, McGraw Hill Education.
2. McKinney R.E. (1962) "Microbiology for Sanitary Engineers", New York McGraw Hill.
3. Sawyer C.N. and McCarty, P.L., (2003), "Chemistry for Environmental Engineering and Science", 5th Edition, Tata McGraw Hill Publishing Co. Ltd., New Delhi.
4. Pelczar M.J, Chan ECS, Krieg, NR(2004) "Textbook of Microbiology" 5th edition Tata McGraw Hill Publishing Co. Ltd., New Delhi.
5. Gaudy and Gaudy (1980), "Microbiology for Environmental Scientists and Engineers", McGraw Hill.
6. APHA, (2012), "Standard Methods for Examination of Water and Wastewater", 22nd Edition.
7. Stumm, W. and Morgan, J.J. (1996) Aquatic Chemistry, Chemical Equilibria and Rates in Natural Waters. 3rd Edition, John Wiley & Sons, Inc., New York.

Course Outcome:

1. Students will be able to analyse the reactions of Environmental chemistry.
2. Students will be able to analyse water and wastewater quality parameters
3. Students will be able to design colloidal system purifier, colorimeter and spectrophotometer
4. Students will be able to analyse titrimetric, gravimetry, Solvent extraction, gas chromatography, HPLC, GC-MS, atomic absorption spectroscopy, ICP-AES, flame photometry and electrophoresis
5. Students will be able to analyse microorganisms, nucleic acids, DNA and RNA and viruses
6. Students will be able to analyse MPN index, M.F. technique and Microbiological Parameters.

Table-1: To establish the correlation between COs & PO's

No. of Curse Outcome (CO)	Course Outcome
PCE41C02.1	Students will be able to analyze the reactions of Environmental chemistry
PCE41C02.2	Students will be able to analyze water and wastewater quality parameters
PCE41C02.3	Students will be able to design colloidal system purifier, colorimeter and spectrophotometer
PCE41C02.4	Students will be able to analyze titrimetric, gravimetry, Solvent extraction, gas chromatography, HPLC, GC-MS, atomic absorption spectroscopy, ICP-AES, flame photometry and electrophoresis
PCE41C02.5	Students will be able to analyze microorganisms, nucleic acids, DNA and RNA and viruses
PCE41C02.6	Students will be able to analyze MPN index, M.F. technique and Microbiological Parameters

Table-2: Correlation between COs & POs

Slight (LOW): 1 Moderate (MEDIUM): 2 Substantial (HIGH): 3 and

for NO CORELATION: '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE41C02.1	3	2	3	2	2	3
PCE41C02.2	3	2	3	2	3	3
PCE41C02.3	3	2	3	3	3	3
PCE41C02.4	3	2	3	3	2	2
PCE41C02.5	3	2	3	3	3	2
PCE41C02.6	3	2	3	3	3	3
Total	**18**	**12**	**18**	**16**	**16**	**16**
Average	**3**	**2**	**3**	**2.67**	**2.67**	**2.67**
Equivalent Avg. Attainment	**3**	**2**	**3**	**3**	**3**	**3**

Table 3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE41C02.1	3	2
PCE41C02.2	3	2
PCE41C02.3	3	2
PCE41C02.4	3	2
PCE41C02.5	3	2
PCE41C02.6	3	2
Total	18	12
Average	3	2
Equivalent Avg. Attainment	**3**	**2**

Core Subject-II

AIR AND NOISE POLLUTION & CONTROL (PCE41C03)

Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses objective:

1. To introduce the students to the basics of air pollution, principles, concepts, and current air pollution issues
2. To have adequate knowledge on composition, structure of the atmosphere and atmospheric stability conditions
3. To have adequate knowledge on various dispersion models and methods adopted in the air quality management.
4. To provide an introduction to design principles and their applications in design of air pollution control system.
5. To have adequate knowledge on current Issues: hazardous air pollutants, CO_2 budgeting, acid rain, ozone layer depletion and global warming
6. To provide an introduction to noise pollution and control measures

Course content:

Unit 1

Introduction - sources, effects on ecosystems, characterization of atmospheric pollutants, air pollution episodes of environmental importance,

Unit 2

Meteorology - composition and structure of the atmosphere, wind circulation, solar radiation, lapse rates, atmospheric stability conditions, wind velocity profile, Maximum Mixing Depth (MMD), Temperature Inversions, Windrose diagram,

Unit 3

General characteristics of stack emissions, plume behavior, Gaussian plume equation, Fick's law of diffusion

Unit 4

Monitoring of particulate matter and gaseous pollutants – respirable, non-respirable and Nano-particulate matter, CO, CO_2, Hydrocarbons (HC), SO_x and NO_x photochemical oxidants, Reactions of pollutants in the atmosphere and their effects- Smoke, smog and ozone layer disturbance, Air quality and emission standards; Air pollution legislation

Unit 5

Pollutant's dispersion models description and application of point, line and areal sources, types of air sampling, sampling train, sampling of particulate and gaseous pollutants, Atmospheric diffusion of pollutants –Transport – Transformation and deposition of air contaminants – Removal processes— Types of dispersion models

Unit 6

Air pollution control equipment for particulate matter & gaseous pollutants – gravity settling chambers, centrifugal collectors, wet collectors, bag house filters, fabric filters, electrostatic precipitator (ESP), adsorption, absorption, scrubbers, condensation and combustion.

Unit 7

Indoor air pollution – Sources and types of indoor air pollutants, control of indoor air pollution

Unit 8

Current Issues: hazardous air pollutants, CO_2 budgeting, Global air pollution: Acid rain, Ozone layer depletion, Global warming, Green house effect and Trans-boundary pollution

Unit 9

Noise – sources, measurements, effects and occupational hazards, standards, Noise mapping, Noise attenuation equations and methods, prediction equations

Unit 10

Noise pollution prevention and control measures, legal aspects and laws related to noise pollution.

References

1. Wark K., Warner C.F., and Davis W.T., (1998), "Air pollution – Its origin and Control", 3rd Edition, Harper & Row Publishers, New York.
2. Lee c.c., and Lin S.D., (2007), "Handbook of Environmental Engineering Calculations", 2nd Edition, McGraw Hill, New York.
3. Perkins H.C. (1974), "Air Pollution", McGraw Hill Higher Education.
4. Crawford M., (1980), "Air Pollution Control Theory", 2nd Edition, Tata McGraw Hill, New Delhi.
5. Stern A.C., (1968), "Air Pollution and Its Effects", 2nd Edition, Vol. I, II, III, Elsevier.
6. Seinfeld N.J., (1975), "Air Pollution", McGraw Hill.

Course outcome:

1. Students will grasp the fundamentals of air pollution and its associated environmental impacts.
2. Students will be able to learn to describe the key concepts of air quality management
3. Students will be able to analyze various types of dispersion models.
4. Students will be able to design gravity settling chambers, centrifugal collectors, wet collectors, bag house filters, fabric filters, electrostatic precipitator etc.
5. Students will be able to analyze on various environmental current Issues.
6. Students will be able to analyze sources, measurements and effects of noise pollution.

Table 1: To establish the correlation between COs & POs

No. of Curse Outcome (CO)	Course Outcome
PCE41C03.1	Students will grasp the fundamentals of air pollution and its associated environmental impacts
PCE41C03.2	Students will be able to learn to describe the key concepts of air quality management
PCE41C03.3	Students will be able to analyze various types of dispersion models
PCE41C03.4	Students will be able to design gravity settling chambers, centrifugal collectors, wet collectors, bag house filters, fabric filters, electrostatic precipitator etc
PCE41C03.5	Students will be able to analyze on various environmental current Issues
PCE41C03.6	Students will be able to analyze sources, measurements and effects of noise pollution

Table-2: Correlation between COs & POs

Slight (LOW): 1 Moderate (MEDIUM): 2 Substantial (HIGH): 3 and for NO CORELATION: '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE41C03.1	3	2	3	2	3	3
PCE41C03.2	3	2	3	3	2	2
PCE41C03.3	3	2	3	3	2	2
PCE41C03.4	3	2	3	2	3	3
PCE41C03.5	3	2	3	3	3	2
PCE41C03.6	3	2	3	3	2	2
Total	**18**	**12**	**18**	**16**	**15**	**14**
Average	**3**	**2**	**3**	**2.67**	**2.5**	**2.33**
Equivalent Avg. Attainment	**3**	**2**	**3**	**3**	**3**	**2**

Table 3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE41C03.1	3	3
PCE41C03.2	3	3
PCE41C03.3	3	3
PCE41C03.4	3	3
PCE41C03.5	3	3
PCE41C03.6	3	3
Total	18	18
Average	3	3
Equivalent Avg. Attainment	**3**	**3**

Elective Paper-I

OPTIMIZATION TECHNIQUE
(PCE61E01)

Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses Objective:

1. To obtain fundamental understanding and application of estimation theory and basic statistics.
2. To be able to interpret the hypothesis testing and its related tests for identification of relationship.
3. To obtain an understanding about different types of correlation coefficient.
4. To demonstrate the ability to apply design of experiment in model formulation.
5. To apply and perform multivariate analysis.
6. To understand the concept of optimization and to learn about different optimization techniques.

Course Content:

Unit- 1

OPERATION RESEARCH:
Introduction, Concept of OR, Decision Theory, Estimators: Unbiasedness, Consistency, Efficiency and Sufficiency, Maximum Likelihood Estimation, Method of moments, Outlier Detection, Model Development Steps.

Unit-2

STATISTICAL TESTS:
Null Hypothesis, Tests based on Normal, t and F distributions for testing of means, variance and proportions, Analysis of r x c tables, Goodness of fit, X-bar, R-Chart, P-Chart, Chi-Square Test.

Unit-3

CORRELATION AND REGRESSION:
Auto-Correlation, Cross Correlation, Auto-Regression and Cross Regression Models, Standard Error, Stochastic Error, Moving Average, Pearson Correlation, Covariance.

Unit-4

DESIGN OF EXPERIMENTS
Analysis of variance, One-way and two-way classifications, Completely randomized design, Randomized block design, Latin square design.

Unit-5

RELAIBILITY AND RISK ANALYSIS:
Reliability analysis methods, Risk Engineering, Random vectors and Matrices, Mean vectors and Covariance matrices, Multivariate Normal density and its properties, Principal components, Components from standardized variables.

Unit- 6

OPTIMIZATION TECHNIQUES:
Introduction to Optimization Technique, Region of Feasibility, Difference between Simulation, Prediction and Optimization, Classification of Optimization Techniques, Linear Programming, Dynamic Programming, Differential Evolution Techniques, Introduction to nature-based optimization techniques, meta-heuristic and heuristic techniques, Particle Swarm Optimization, Ant Colony Optimization, Fire Fly Algorithm.

References:

1. Handbook of Engineering Statistics. Hoang Pham, Springer London Ltd, 2022, 3rd Edition.
2. Engineering Optimization: Theory and Practice, Singiresu S. Rao, John Wiley & Sons, Inc, 2019, Fifth Edition.
3. A First Course in Optimization Theory, Rangarajan K. Sundaram, Cambridge University Press, 1996, First Edition.
4. Modeling Hydrologic Change: Statistical Methods, Richard H. McCuen, CRC Press, 2002, First Edition.
5. Statistics for Engineers: An Introduction, Jim Morrison, Wiley, 2009. First Edition
6. Introduction to Operations Research, Frederick S. Hillier, Gerald J. Lieberman, Bodhibrata Nag, Preetam Basu, McGraw Hill Education, 2017, 10th Edition.

Course Outcome:

1. Students will be able to apply different concepts of operational research, estimators and detect outliers.
2. Students will be able to develop an idea and know the procedure of developing statistical tests and hypothesis.
3. Students will be able to apply correlations and regression coefficients for initial analysis of model development and feasibility.
4. Students will be able to generate designs for experimental analysis followed by model development and testing.
5. Students will be able to analyze the risk and reliability of a project.

6. Students will be able to optimize and suggest the best variations for maximization of profit and minimization of cost from a system.

Table 1: To establish the correlation between COs & POs

No. of Curse Outcome (CO)	Course Outcome
PCE41E01-01.1	Students will be able to apply different concepts of operational research, estimators and detect outliers
PCE41E01-01.2	Students will be able to develop an idea and know the procedure of developing statistical tests and hypothesis.
PCE41E01-01.3	Students will be able to apply correlations and regression coefficients for initial analysis of model development and feasibility.
PCE41E01-01.4	Students will be able to generate designs for experimental analysis followed by model development and testing.
PCE41E01-01.5	Students will be able to analyze the risk and reliability of a project.
PCE41E01-01.6	Students will be able to optimize and suggest the best variations for maximization of profit and minimization of cost from a system

Table-2: Correlation between COs & Pos Slight (LOW): 1 Moderate (MEDIUM): 2 Substantial (HIGH): 3 and for NO CORELATION: '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE41E01-01.1	3	2	3	3	3	3
PCE41E01-01.2	3	3	3	3	3	3
PCE41E01-01.3	3	2	3	3	3	3
PCE41E01-01.4	3	3	3	3	3	1
PCE41E01-01.5	3	3	3	3	3	3
PCE41E01-01.6	3	3	3	3	3	3
Total	18	16	18	18	18	16
Average	3	2.66	3	3	3	2.7
Equivalent Avg. Attainment	**3**	**3**	**3**	**3**	**3**	**3**

Table 3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE41E01-01.1	2	2
PCE41E01-01.2	3	3
PCE41E01-01.3	3	3
PCE41E01-01.4	3	3
PCE41E01-01.5	3	3
PCE41E01-01.6	3	3
Total	18	18
Average	3	3
Equivalent Avg. Attainment	**3**	**3**

ADVANCED MATHEMATICS
(PCE41E01-02)

Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Course Objective

1. Introduce students to ordinary differential equations and the methods for solving these equations Use differential equations as models for real world phenomena
2. Integrate the knowledge accumulated in the calculus sequence to solve applied problems
3. Introduce the fundamentals of Linear Algebra and Complex Analysis
4. Provide a rigorous introduction to upper level mathematics which is necessary for students of engineering, physical sciences and mathematics.

Course Content

Unit-1
Calculus of Variations – Variation and its properties – Euler's equation – Conditional extreme – Isoperimetric problems – Functional dependant on first and higher order derivatives – Functional dependent on functions of several independent variables – some applications – Direct methods – Ritz and Kantorovich methods, Euler's finite difference method.

Unit-2
Laplace Transforms and Fourier Transforms. Application of Fourier Transform in solving initial and boundary value problems. Laplace Equation, Heat equation and wave equation.

Unit-3
Hankel's Transform, elementing properties of Hankel transforms, Hankel inversion and transform theorems. Hankel transforms of derivatives of functions. Parsevel's theorem. Hankel transforms of $\frac{d^2f}{d\,x^2} + \frac{1}{x}\frac{df}{dx} = \frac{n^2}{x^2}f$.

Unit-4
Simulation – Types, case studies in various fields using simulation techniques, simulation softwares used, use of mathematical models based on probabilistic and statistical methods. Partial Differential Equations – Formation of PDE, Solutions of PDE, Equations solvable by direct integration, Linear equations of the first order, Non-linear equations of the first order, Charpit's

Method, Homogeneous Linear equations with constant coefficient, Non-Homogeneous Linear equations, Non-Linear equations of the second order.

Unit-5

Solution of Parabolic and Hyperbolic equations – Implicit and Explicit Schemes, ADI methods, Non Linear parabolic equations – Iteration method, Solution of elliplic equation – Jacobi method, Gauss - Seidel & SOR method. Richardson method, RKF4.

Unit-6

Introduction to finite element method and its scope.

References:

1. Kreyszig Erwin, Advanced Engineering Mathematics, John Wiley & Sons (Asia) Pvt Ltd, JOHN WILEY & SONS, INC, 2010, 10th Edition.
2. Krishnamurthy & Sen, Numerical Algorithms, Afiliated East-west press private Limited, New Delhi, 2008, 10th Edition.
3. Ramana, B. V., Higher Engineering Mathematics, The McGraw-Hill Companies, New-Delhi, 2011, 1st Edition.

Course Outcome

1. To utilize various methods for solving ODEs and solve initial value problems, understand the existence and uniqueness of such solutions and to Recognize ODEs of varying order and use these to solve problems involving population dynamics, oscillation of a spring and resistance in a circuit
2. Ability to Work with and solve homogeneous and non-homogeneous ODEs and systems of ODEs. Moreover, to learn additional methods for solving ODEs including Euler's method, the power series method and Laplace transforms.
3. Perform basic operations with matrices, find the inverse of a matrix, determinant of a square matrix, as well as Eigen values and Eigen vectors and investigate associated applications, and to use matrices to solve systems of equations.
4. Express complex numbers in trigonometric and polar form, and to perform operations with complex numbers, including finding the roots of unity.
5. Explore functions of a single complex variable and calculate derivatives of analytic functions
6. Calculate line integrals in the complex plane, and Study Cauchy-Riemann equations, Cauchy's integral theorem and Cauchy's integral formula.

Table 1: To establish the correlation between COs & POs

No. of Curse Outcome (CO)	Course Outcome
PCE41E01-02.1	To utilize various methods for solving ODEs and solve initial value problems, understand the existence and uniqueness of such solutions and to Recognize ODEs of varying order and use these to solve problems involving population dynamics, oscillation of a spring and resistance in a circuit
PCE41E01-02.2	Ability to Work with and solve homogeneous and non-homogeneous ODEs and systems of ODEs. Moreover, to learn additional methods for solving ODEs including Euler's method, the power series method and Laplace transforms
PCE41E01-02.3	Perform basic operations with matrices, find the inverse of a matrix, determinant of a square matrix, as well as eigen values and eigen vectors and investigate associated applications, and to use matrices to solve systems of equations
PCE41E01-02.4	Express complex numbers in trigonometric and polar form, and to perform operations with complex numbers, including finding the roots of unity
PCE41E01-02.5	Explore functions of a single complex variable and calculate derivatives of analytic functions
PCE41E01-02.6	Calculate line integrals in the complex plane, and Study Cauchy-Riemann equations, Cauchy's integral theorem and Cauchy's integral formula

Table-2: Correlation between COs & Pos

Slight (LOW): 1 Moderate (MEDIUM): 2 Substantial (HIGH): 3 and for NO CORELATION: '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE41E01-02.1	2	2	3	2	2	2
PCE41E01-02.2	2	2	3	2	2	2
PCE41E01-02.3	2	2	3	2	2	2
PCE41E01-02.4	2	2	3	2	2	2
PCE41E01-02.5	2	2	3	2	2	2
PCE41E01-02.6	2	2	3	2	2	2
Total	12	12	18	12	12	12
Average	2	2	3	2	2	2
Equivalent Avg. Attainment	**2**	**2**	**3**	**2**	**2**	**2**

Table 3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE41E01-02.1	2	2
PCE41E01-02.2	1	1
PCE41E01-02.3	1	2
PCE41E01-02.4	2	3
PCE41E01-02.5	2	2
PCE41E01-02.6	2	3
Total	10	13
Average	1.67	2.16
Equivalent Avg. Attainment	**2**	**2**

COMPUTATIONAL FLUID DYNAMICS
(PCE41E01-03)

Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Course objectives:

1. To know fundamentals of CFD techniques for solving incompressible and compressible N-S equation.
2. To have adequate knowledge on fluid continuum, flux, mass, momentum and energy conservation using RTT.
3. To have sufficient knowledge on different types of governing equations for movement of fluid.
4. To have understanding of various types of discretization concept, methods, equations, schemes and boundary conditions.
5. To have better understanding of various series, accuracy, error, and Laplas, Gauss, Jacobbi methods etc. for approximation of a derivative.
6. To have basic knowledge of different types of finite volume method.

Course content:

Unit 1

What is CFD? Comparison of CFD with theoretical and experimental approaches, application of CFD. Fluid continuum, control volume system, material derivative, flux, Reynolds transport theorem, derivation of the conservation equations of mass, momentum and energy by using Reynold's transport theory (RTT), surface force, body force, governing equations in vector and indicial forms, conservative and non conservative form of governing equations, stress tensor and second viscosity, inner and outer product in indicial notations, types of governing equations-parabolic, elliptic, hyperbolic or mixed, unsteady, diffusion, convection and source terms.

Unit 2

Exact or continuum equations, approximate equations and approximate solutions, concept of discretization, various type of boundary conditions, discretization of equations, boundary conditions, initial condition and the domain, various methods of discretization, comparison of basic discretization methods such as finite difference, finite volume and finite element. Basic layout of the discretization and solution of algebraic equations for a

typical CFD problem. Different types of discretisation scheme: SIMPLE, SIMPLEC, PISO, HYBRID.

Unit 3

Finite difference method, smooth function & Taylor series, forward, backward, central difference approximations of a derivative, order of accuracy, truncation error, round of error, discretization error, numerical stability, numerical diffusion, artificial viscosity, higher order approximations of a derivative, solution of Laplace or Poisson equations using FDM, Space matrix, Gauss elimination, Gauss Seidel, TDMA, Jacobbi method, Crank Nicolson method, ADI method, equilibrium and marching problems, convergence criterion, relaxation (over, under, no), implicit and explicit methods, approximations for time derivative, stability analysis, courant number, examples of conditionally stable, unconditionally stable.

Unit 4

Introduction to finite volume method, discretization of 1D convection-diffusion equations, Cell Peclet number, upwinding, central difference, exponential scheme etc. so that central difference for convection terms gives unstable solution, calculation of the range of Pe no. for cell solution using central difference. Variational methods, weight function, save function, Galerkin formulation, PETROV Galerkin formulation, WEAK form, example of solution of POISSON equation for a square domain using FEM, stream. Stream function, vorticity formulation, solution of Lid-driven cavity problem using sie-wemega formulation and FDM, solution of Navier Stokes equations, sequential method, coupled method, pressure-velocity coupling, staggard mesh, collocated mesh, Checker board modes, SIMPLE Algorithm

References:

1. K. Muralidhar, T. Sundararajan, (2011), “Computational Fluid Flow and Heat Transfer”, Second Edition, Rosa Publications.

2. Chung T. J., (2014), “Computational Fluid Dynamics”, 2nd Edition, Cambridge University Press.

3. Tapan K. Sengupta, (2005), “Computational Fluid Dynamics” University Press.

4. Hirch C., (2007), “Numerical Computation of Internal and External Flows” 2nd Edition, Butterworth-Heinemann.

Course outcomes (CO):

1. Students will be able to understand fundamentals of CFD techniques for solving incompressible and compressible N-S equation.
2. Students will be able to understand fluid continuum, flux, mass, momentum and energy conservation using RTT.
3. Students will have adequate knowledge of different types of governing equations for movement of fluid.
4. Students will have understanding of various types of discretization concept, methods, equations, schemes and boundary conditions.
5. Students will have understanding of various series, accuracy, error, and Laplas, Gauss, Jacobbi methods etc. for approximation of a derivative.
6. Students will have sufficient knowledge of different types of finite volume method.

Table 1: To establish the correlation between COs & POs

No. of Curse Outcome (CO)	Course Outcome
PCE41E01-03.1	Students will be able to understand fundamentals of CFD techniques for solving incompressible and compressible N-S equation.
PCE41E01-03.2	Students will be able to understand fluid continuum, flux, mass, momentum and energy conservation using RTT.
PCE41E01-03.3	Students will have adequate knowledge of different types of governing equations for movement of fluid.
PCE41E01-03.4	Students will have understanding of various types of discretization concept, methods, equations, schemes and boundary conditions.
PCE41E01-03.5	Students will have understanding of various series, accuracy, error, and Laplas, Gauss, Jacobbi methods etc. for approximation of a derivative.
PCE41E01-03.6	Students will have sufficient knowledge of different types of finite volume method.

Table-2: Correlation between COs & POs

Slight (LOW): 1 Moderate (MEDIUM): 2 Substantial (HIGH): 3 and for NO CORELATION: '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE41E01-03.1	2	3	3	2	3	3
PCE41E01-03.2	2	3	3	2	3	2
PCE41E01-03.3	2	3	3	2	2	3
PCE41E01-03.4	3	3	3	2	3	3
PCE41E01-03.5	2	3	3	2	2	3
PCE41E01-03.6	2	3	3	2	3	3
Total	13	18	18	12	16	17
Average	2.17	3.00	3.00	2.00	2.67	2.83
Equivalent Avg. Attainment	**2**	**3**	**3**	**2**	**3**	**3**

Table 3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE41E01-03.1	3	3
PCE41E01-03.2	3	4
PCE41E01-03.3	3	4
PCE41E01-03.4	3	3
PCE41E01-03.5	3	4
PCE41E01-03.6	3	4
Total	18	22
Average	3	3.67
Equivalent Avg. Attainment	**3**	**4**

GLOBAL WARMING AND CLIMATE CHANGE
(PCE41E01-04)

Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses objective:

1. To make the students understand about the sources of energy.
2. To have adequate knowledge on effects of greenhouse gases.
3. To have adequate knowledge on impacts of climate change.
4. To acquire knowledge on modeling on climate change.
5. To understand rules and protocols on global trading related to global warming.
6. To understand the basic of clean environmental mechanism and alternatives techniques.

Course Content:

Unit 1

Energy Sources: Global Warming Potential, Energy Issues and Climate Change, Alternate Energy Sources.

Unit 2

Green-House Effect: Green house as natural phenomenon, Green House Gases (GHGs) and their Emission, Sources. Quantification of CO_2 Emission, Global Warming Potential (GWP) of GHGs.

Unit 3

Impacts of Climate Change: Effects on climatic and related changes of Global and India, Temperature Rise. Sea Level rise, Coastal Erosion and landslides, Coastal Flooding. Wetlands and Estuaries loss.

Unit 4

Modeling on Climatic Change: Case studies on climate change case studies, Data analysis, Interpretation, Modeling on climate change, Ozone layer depletion and its control.

Unit 5

Kyoto Protocol: Importance. Significance and its role in Climate Change.

Unit 6

Carbon Credit & Trading: Mechanisms, Various Models (European, Indian) Global and Indian Scenario.

Unit 7

Cleaner Development Mechanisms: Various Projects related to CO_2 Emission Reduction.

Unit 8

Alternatives of Carbon Sequestration - Conventional and non-conventional techniques, Role of Countries and Citizens in Containing Global Warming.

References:

1. Barry R.G., and Chorley R.L., (2017), "Atmosphere, Weather and Climate", 4th Edition, ELBS Publication.
2. Bolin B., (Ed.), (1981), "Carbon Cycle Modeling", John Wiley and Sons Publications.
3. Corell R.W., and Andenon P.A., (Eds). (1991), "Global Environmental Change", Springer Vetlog Publishers.
4. Francis D., (2000), "Global Warming: The Science and Climate Change", 1st Edition, Oxford University Press.
5. Frane B., Medury Y., and Joshi Y., (Eds.), (1992), "Global Climate Change: Science, Impact and Responses", Tata Energy Research Institute, New Delhi.
6. Linden E., (2007), "The Winds of Change: Climate, Weather and the Destruction of Civilizations", Simon and Schuster Publications.
7. Mintzer I.M., (Ed.), (1992), "Confronting Climate Change, Risks, Implications and Responses", Cambridge University Press.
8. Srivatsava A.K., (2009), "Global Warming", First Edition, APH Publications.
9. Wyman R.L., (Ed.), (1991), "Global Climate Change and Life on Earth", First Edition, Springer, Chapman and Hall Publications.
10. Yadav, Chander and Bhan, (2005), "Global Warming India's Response and Strategy", RPH Publications.

Course outcome:

1. Students will be able to understand about the sources of energy.
2. Students will be able to gather knowledge on effects of greenhouse gases.
3. Students will be able to knowledge on impacts of climate change.
4. Students will be able to knowledge on modeling on climate change.
5. Students will be able to understand rules and protocols on global trading related to global warming.
6. Students will be able to know about the basic of clean environmental mechanism and alternatives techniques.

Table 1: To establish the correlation between COs & POs

No. of Curse Outcome (CO)	Course Outcome
PCE41E01-04.1	Students will be able to understand about the sources of energy.
PCE41E01-04.2	Students will be able to gather knowledge on effects of greenhouse gases.
PCE41E01-04.3	Students will be able to knowledge on impacts of climate change.
PCE41E01-04.4	Students will be able to knowledge on modeling on climate change.
PCE41E01-04.5	Students will be able to understand rules and protocols on global trading related to global warming.
PCE41E01-04.6	Students will be able to know about the basic of clean environmental mechanism and alternatives techniques.

Table-2: Correlation between COs & POs

Slight (LOW): 1 Moderate (MEDIUM): 2 Substantial (HIGH): 3 and for NO CORELATION: '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE41E01-04.1	2	3	3	2	3	3
PCE41E01-04.2	2	3	3	3	3	3
PCE41E01-04.3	2	3	2	3	3	3
PCE41E01-04.4	2	3	3	3	3	3
PCE41E01-04.5	2	3	2	3	3	3
PCE41E01-04.6	2	3	3	2	3	3
Total	12	18	16	16	18	18
Average	2.00	3.00	2.67	2.67	3.00	3.00
Equivalent Avg. Attainment	**2**	**3**	**3**	**3**	**3**	**3**

Table 3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE41E01-04.1	4	2
PCE41E01-04.2	4	2
PCE41E01-04.3	4	2
PCE41E01-04.4	4	2
PCE41E01-04.5	4	2
PCE41E01-04.6	4	2
Total	24	12
Average	4	2
Equivalent Avg. Attainment	**4**	**2**

WATER POLLUTION LABORATORY-I
(PCE41P01)

Total Credit: 02
Contact Periods: 03 (0L+0T+3P)

Courses Objective:

1. To determine the pH, acidity, alkalinity, and hardness of water samples
2. To determine the TS, TSS, TDS, Conductivity, and turbidity of water samples.
3. To determine the DO, BOD, COD, and TOC of water and wastewater samples.
4. To measure the residual chlorine concentration of water samples.
5. To measure chloride, sulphate, nitrate, and phosphate of water and wastewater samples.
6. To measure MPN, Coliform and other indicator organisms of water and wastewater samples.

Course Content:

List of Experiments:

1. Determination of pH, acidity, alkalinity, and hardness of water samples.
2. Determination of TS, TSS, TDS, conductivity, and turbidity, of water samples.
3. Determination of DO, BOD, COD of water and wastewater samples.
4. Determination of TOC of water and wastewater samples.
5. Determination of residual chlorine of water samples.
6. Determination of chloride, nitrate, and phosphate of water and wastewater samples.
7. Determination of MPN, Coliform and other indicator organisms of water and wastewater samples.

Course Outcome:

1. Students will be able to determine Residual Chlorine of water samples.
2. Students will be able to determine various water quality parameters like pH, acidity, alkalinity, and hardness.
3. Students will be able to determine TS, TSS, TDS, conductivity, and turbidity of water samples
4. Students will be able to determine DO, BOD, COD, TOC of water and wastewater samples.
5. Students will be able to determine chloride, sulphate, nitrate, and phosphate of water and wastewater samples.

6. Students will be able to determine MPN, Coliform and other indicator organisms of water and wastewater samples.

Table 1: To establish the correlation between COs & POs

No. of Curse Outcome (CO)	Course Outcome
PCE41P01.1	Students will be able to determine Residual Chlorine of water samples.
PCE41P01.2	Students will be able to determine various characterizing parameters of water sample like pH, acidity, alkalinity, hardness.
PCE41P01.3	Students will be able to determine TDS, Conductivity, turbidity, color, odor, temperature of water samples
PCE41P01.4	Students will be able to determine DO, BOD, COD, TOC of water samples.
PCE41P01.5	Students will be able to determine Chloride, Sulfate, nitrogenous compounds of water samples.
PCE41P01.6	Students will be able to determine MPN, Coliform and other indicator organisms of water samples

Table-2: Correlation between COs & POs

Slight (LOW): 1 Moderate (MEDIUM): 2 Substantial (HIGH): 3 and

for NO CORELATION: '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE41P01.1	3	2	3	3	3	2
PCE41P01.2	3	3	2	3	3	2
PCE41P01.3	2	2	2	2	2	3
PCE41P01.4	3	3	3	2	2	3
PCE41P01.5	3	3	3	3	3	3
PCE41P01.6	3	3	3	3	3	3
Total	**17**	**16**	**16**	**16**	**16**	**16**
Average	**2.83**	**2.67**	**2.67**	**2.67**	**2.67**	**2.67**
Equivalent Avg. Attainment	**3**	**3**	**3**	**3**	**3**	**3**

Table 3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE41P01.1	2	2
PCE41P01.2	2	2
PCE41P01.3	2	2
PCE41P01.4	2	2
PCE41P01.5	2	2
PCE41P01.6	2	2
Total	12	12
Average	2	2
Equivalent Avg. Attainment	**2**	**2**

COMPUTER LABORATORY

(PCE41P02)

Total Credit: 02
Contact Periods: 03 (0L+0T+3P)

Courses Objective:

1. To gain knowledge about Design Expert
2. To gain knowledge about ArcGIS
3. To gain knowledge about to gain knowledge about Chemdraw
4. To gain knowledge about QUAL2K
5. To gain knowledge about MATLAB
6. To gain knowledge about Origin, sigma plot, WRPLOT

Course Content:

Demonstration and practice of several environmental engineering analysis and design software like Design Expert, ArcGIS, Chemdraw, QUAL2K, MATLAB, Origin, sigma plot, WRPLOT, and reference editing software's like Mendeley etc. Additionally, other software as per requirement may be added in the course.

Course Outcome:

1. Students will be able to use Design Expert software to solve various problem in Environmental Engineering.
2. Students will be able to use ArcGIS software to solve various problem in Environmental Engineering.
3. Students will be able to use Chemdraw software to solve various problem in Environmental Engineering.
4. Students will be able to use QUAL2K software to solve various problem in Environmental Engineering.
5. Students will be able to use MATLAB software to solve various problem in Environmental Engineering.
6. Students will be able to use Origin, sigma plot, WRPLOT software to solve various problem in Environmental Engineering.

Table 1: To establish the correlation between COs & Pos

No. of Curse Outcome (CO)	Course Outcome
PCE41P02.1	Students will be able to use Design Expert software to solve various problems in Environmental Engineering.
PCE41P02.2	Students will be able to use ArcGIS software to solve various problems in Environmental Engineering.
PCE41P02.3	Students will be able to use Chemdraw software to solve various problems in Environmental Engineering.
PCE41P02.4	Students will be able to use QUAL2K software to solve various problems in Environmental Engineering.
PCE41P02.5	Students will be able to use MATLAB software to solve various problems in Environmental Engineering.
PCE41P02.6	Students will be able to use Origin, sigma plot, WRPLOT software to solve various problems in Environmental Engineering.

Table-2: Correlation between COs & POs

Slight (LOW): 1 Moderate (MEDIUM): 2 Substantial (HIGH): 3 and for NO CORELATION: '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE41P02.1	3	3	3	2	3	3
PCE41P02.2	2	3	3	2	3	3
PCE41P02.3	2	2	2	3	2	2
PCE41P02.4	3	3	3	3	3	3
PCE41P02.5	3	3	2	3	3	3
PCE41P02.6	3	3	3	3	2	2
Total	**16**	**17**	**16**	**16**	**16**	**16**
Average	**2.67**	**2.83**	**2.67**	**2.67**	**2.67**	**2.67**
Equivalent Avg. Attainment	**3**	**3**	**3**	**3**	**3**	**3**

Table 3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE41P02.1	3	3
PCE41P02.2	3	3
PCE41P02.3	3	3
PCE41P02.4	3	3
PCE41P02.5	3	3
PCE41P02.6	3	3
Total	18	18
Average	3	3
Equivalent Avg. Attainment	**3**	**3**

SEMINAR
(PCE41P03)

Total Credit: 01
Contact Periods: 02 (0L+0T+2P)

Course Content:

Each student will perform presentations in seminar on the topics related to the field of Environmental Engineering in order to improve their presentation skills.

Syllabus for M.TECH (Environmental Engineering)
Second Semester

Sl. No.	Subject	Credit	Class Hours per Week	Marks
1	**Basic Core** **PCE42C01:** Water and wastewater Treatment Processes-II	4	4	100
2	**Core Subject-I** **PCE42C02:** Solid and Hazardous Waste Management	4	4	100
3	**Core Subject-II** **PCE42C03:** Ecology & Environmental Impact Assessment	4	4	100
4	**Elective Paper-III (PCE42E01)** One course from Elective Group (excluding the course already selected as Elective II)	4	4	100
5	**PCE42P01:** Water Pollution Laboratory-II	2	3	100
6	**PCE42P02:** Air Pollution Laboratory	2	3	100
7	**PCE42P03:** Comprehensive Viva-voice	2	0	100
8	**PCE42P04:** Project Preliminaries	3	6	100
	Total	**25**	**28**	**800**

Basic Core

WATER AND WASTEWATER TREATMENT PROCESSES-II (PCE42C01)

Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses objective:

1. To understand the basic characteristics of wastewater
2. To study design principle of screen, equalization basin, grit chamber and sedimentation tank.
3. To study the Kinetics of biological system.
4. To have adequate knowledge on principles and design of suspended growth system.
5. To have adequate knowledge on principles and design of attached growth system.
6. To study various rural wastewater treatment system

Course Content:

Unit 1

Objectives of wastewater treatment - characteristics, flow variations, types of reactors, CSTR and PFR reactors analysis, Wastewater Treatment Flow Diagrams and Hydraulic Profile.

Unit 2

Theoretical Principles and Design – screens, equalization basin, grit chamber, primary and secondary settling tanks.

Unit 3

Kinetics of biological treatment systems – biokinetic constants and their determination, batch and continuous systems.

Unit 4

Theoretical principles and design – suspended growth system – conventional activated sludge process and its modifications.

Unit 5

Theoretical principles and design – attached growth system – trickling filter, bio-towers and rotating biological contractors, Principles and design of stabilization ponds.

Unit 6

Sludge Processing – separation – sludge thickeners, volume reduction, conditioning and digestion – aerobic and anaerobic.

Unit 7

Advanced Wastewater Treatment – Need and Technologies used, Nitrification and Denitrification Processes, Phosphorous removal. Wastewater disinfection.

Unit 8

Rural wastewater systems – septic tanks, two-pit latrines, eco-toilet, soak pits.

References:

1. Benefield R.D., and Randal C.W., (1980), "Biological process Design for Wastewater Treatment", Prentice Hall, Englewood Chiffs, New Jersey.
2. Metcalf and Eddy Inc., (2012), "Wastewater Engineering – Treatment and Reuse", 4th Edition, Tata McGraw Hill Publishing Co. Ltd., New Delhi.
3. Karia G.L., and Christian R.A., (2013), "Wastewater Treatment Concepts and Design Approach", 2nd Edition, Prentice Hall India Learning Pvt Ltd., New Delhi.
4. Ronand L., and Droste, (1997), "Theory and Practice of Water and Wastewater Treatment", John Wiley and Sons Inc.
5. Fair G.M., Geyer J.G and Okun, (2010), "Water-wastewater Engineering" 3rd Edition, John Wiley Publications.
6. Lee c.c., and Lin S.D., (2007), "Handbook of Environmental Engineering Calculations", 2nd Edition, McGraw Hill, New York.
7. Gaudy, (1972) "Advanced Wastewater Treatment".
8. "Industrial Safety and Pollution Control Handbook", (1991), National Safety Council and Associate (Data) Publishers Pvt. Ltd.

Course outcome:

1. Students will be able to analyze characteristics of wastewater.
2. Students will be able to design screen, equalization basin, and sedimentation tank for wastewater treatment.
3. Students will be able to analyze biokinetics parameter of biological system.
4. Students will be able to design various biological units of suspended and attached growth system.
5. Students will be able to design various biological units of batch and continuous systems.
6. Students will be able to design various units of rural wastewater system.

Table 1: To establish the correlation between COs & POs

No. of Curse Outcome (CO)	Course Outcome
PCE42C01.1	Students will be able to analyze characteristics of wastewater.
PCE42C01.2	Students will be able to design screen, equalization basin, and sedimentation tank for wastewater treatment.
PCE42C01.3	Students will be able to analyze biokinetics parameter of biological system.
PCE42C01.4	Students will be able to design various biological units of suspended and attached growth system.
PCE42C01.5	Students will be able to design various biological units of batch and continuous systems.
PCE42C01.6	Students will be able to design various units of rural wastewater system.

Table-2: Correlation between COs & POs

Slight (LOW): 1 Moderate (MEDIUM): 2 Substantial (HIGH): 3 and

for NO CORELATION: '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE42C01.1	3	2	3	2	3	3
PCE42C01.2	3	2	3	3	2	2
PCE42C01.3	3	2	3	3	2	2
PCE42C01.4	3	2	3	2	3	3
PCE42C01.5	3	2	3	3	3	2
PCE42C01.6	3	2	3	3	2	2
Total	18	12	18	16	15	14
Average	3	2	3	2.67	2.5	2.33
Equivalent Avg. Attainment	**3**	**2**	**3**	**3**	**3**	**2**

Table 3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE42C01.1	4	3
PCE42C01.2	4	3
PCE42C01.3	4	3
PCE42C01.4	4	3
PCE42C01.5	4	3
PCE42C01.6	4	3
Total	24	18
Average	4	3
Equivalent Avg. Attainment	**4**	**3**

Core Subject-I

SOLID AND HAZARDOUS WASTE MANAGEMENT (PCE42C02)

Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Course objective:

1. To have basic understanding on sources, characteristics and effects of solid waste.
2. To study the collection system of solid waste, various waste transformation and treatment methods of solid waste.
3. To have adequate knowledge on E-waste and Bio-medical waste management.
4. To have adequate knowledge on legislation related to solid and hazardous waste management.
5. To study the treatment and disposal methods of hazardous waste.

Course content:

Solid Waste Management

Unit 1

Evolution of Solid Waste Management: Sources/Types and Characteristics; Generation; Handling, Separation, storage, and Processing at source.

Unit 2

Collection and Transportation: Primary and secondary collection; Transfer and Transport.

Unit 3

Processing and Treatment: Separation and unit operations; Chemical Transformation (combustion/incineration); Biological treatment (Composting, Anaerobic digestion).

Unit 4

Special Waste: E-waste management, Plastic and Bio-medical waste management, Street sweeping waste.

Unit 5

Disposal and Legislation: Landfilling; Rules and legislation; Integrated solid waste management (ISWM).

Hazardous Waste Management

Unit 6

Evolution of Hazardous Waste Management: Definition; sources/types, generation; classification; Magnitude of problem; Risk assessment.

Unit 7

Collection, processing and treatment: on-site storage, collect and transportation; Physical, Chemical, Thermal and Biological treatment processes.

Unit 8

Hazardous waste disposal: Ground water contamination; disposal methods (Secured landfill, combustion, Solidification and Stabilization).

References:

1. Tchobanoglous G., Theissen H., and Eliassen R. (1993), "Solid Waste Engineering – Principles and Management Issues", 1st Edition, McGraw Hill, New York.
2. Pavoni J.L (1993)., "Handbook of Solid Waste Disposal".
3. Peavy, Rowe and Tchobanoglous (2013), "Environmental Engineering", McGraw Hill Co, 4th Edition.
4. Mantell C.L., (1975), "Solid Waste Management", John Wiley.
5. CPHEEO, Manual on Municipal Solid Waste Management, Central Public Health and Environmental Engineering Organization, Government of India, New Delhi, 2016.
6. WHO (2017) Manual on Solid Waste Management.
7. Vesiland A. (2016), "Solid Waste Engineering", Thompson Books, 2nd Edition.
8. Hazardous waste (Management and Handling) rules, 2001.
9. Bio-medical Waste Management Rules 2016, CPCB.

Course outcome:

1. Students will be able to understand the sources, characteristics and effects of solid waste.
2. Students will be able to understand the collection system of solid waste, various waste transformation and treatment methods of solid waste.
3. Students will be given a broad idea regarding E-waste and Bio-medical waste management.

4. Students will be given a broad idea on legislation related to solid and hazardous waste management.
5. Students will be given a broad idea regarding the treatment and disposal methods of hazardous waste.

Table 1: To establish the correlation between COs & Pos

No. of Curse Outcome (CO)	Course Outcome
PCE42C02.1	Students will be able to understand the sources, characteristics and effects of solid waste.
PCE42C02.2	Students will be able to understand the collection system of solid waste, various waste transformation and treatment methods of solid waste.
PCE42C02.3	Students will be given a broad idea regarding E-waste and Bio-medical waste management.
PCE42C02.4	Students will be given a broad idea on legislation related to solid and hazardous waste management.
PCE42C02.5	Students will be given a broad idea regarding the treatment and disposal methods of hazardous waste.

Table-2: Correlation between COs & POs

Slight (LOW): 1 Moderate (MEDIUM): 2 Substantial (HIGH): 3 and for NO CORELATION: '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE42C02.1	3	2	3	3	2	2
PCE42C02.2	3	2	3	3	3	3
PCE42C02.3	3	2	3	2	3	2
PCE42C02.4	3	2	3	3	2	3
PCE42C02.5	3	2	3	2	3	3
Total	**15**	**10**	**15**	**13**	**13**	**13**
Average	**3**	**2**	**3**	**2.6**	**2.6**	**2.6**
Equivalent Avg. Attainment	**3**	**2**	**3**	**3**	**3**	**3**

Table 3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE42C02.1	4	3
PCE42C02.2	4	3
PCE42C02.3	4	3
PCE42C02.4	4	3
PCE42C02.5	4	3
Total	20	15
Average	4	3
Equivalent Avg. Attainment	**4**	**3**

Core Subject-II

ECOLOGY & ENVIRONMENTAL IMPACT ASSESSMENT (PCE42C03)

Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Course objectives:

1. To make the students able to understand structure and function of ecosystem in conservation of different kind of Environmental system.
2. To have adequate knowledge on principles, modeling and application of ecological engineering.
3. To have adequate knowledge on scope and contents, methodologies and techniques of Environmental Impact Assessment.
4. To have understanding of prediction and assessment of impacts on the surface water environment.
5. To have understanding of prediction and assessment of impacts on the air environment.
6. To have understanding of prediction and assessment of impacts on the land environment.
7. To understand the basics of risk characterisation and risk reduction.
8. To have sufficient knowledge of case studies related to Environmental Impact Assessment.

Course content:

Unit 1

Ecology – Classification of Ecosystems, Structure and Function of Ecosystems, Energy Flow in Ecosystems, Ecological Niche and succession, Bio-geo-chemical cycles, Ecological Pyramids.

Unit 2

Ecosystems – Biotic and abiotic components, production and consumption, trophic levels, productivity and energy flow, food webs, cycling of elements.

Unit 3

Changes in ecosystems – Succession, long range changes, long range stability, the organization and dynamics of ecological communities, description and study of typical natural and artificial ecosystems.

Unit 4

Principles of ecological engineering – Principles, components and characteristics of Systems - Classification of systems - Structural and functional interactions of environmental systems - Environmental systems as energy systems - Mechanisms of steady-state maintenance in open and closed systems - Modelling and ecotechnology - Elements of modelling - Modelling procedure - Classification of ecological models - Applications of models in ecotechnology - Ecological economics.

Unit 5

Aquatic and Terrestrial Ecosystems – Diversity and dominance Indices, Ecosystem Models.

Unit 6

Climate change and biodiversity, Application of ecological engineering – Ecosanitation - Principles and operation of soil infiltration systems - Wetlands and ponds - Source separation systems - Aquacultural systems - Detritus based treatment for solid wastes - Applications of ecological engineering for marine systems.

Unit 7

Lake Ecosystem – trophic levels, nutrient loading, nutrient enrichment, Leibig's Law, control of eutrophication.

Unit 8

Environmental Impact Assessment – Definition, Objectives, Types – Rapid and Comprehensive EIA, EIS, FONSI, Step-by-step procedure for conducting EIA and Limitations of EIA, Prevention of Significant Deterioration (PSD) Programme.

Unit 9

Frame work of Impact Assessment – scope and contents of EIA, methodologies and techniques of EIA.

Unit 10

Prediction and Assessment of Impacts on the Surface Water Environment – Quality Impacts, Quantity Impacts, Water Quality Index, Mass Balances, Quantitative Modeling, Water Conservation - Case Study. Prediction and Assessment of Impacts on the Groundwater Environment: Hydrogeological Information, Vulnerability Mapping, Subsurface Transport and Fate.

Unit 11

Prediction and Assessment of Impacts on the Air Environment – Air Pollutants Emission, Ambient Air Quality and Standards, Emission Inventories, Meteorological Data, Mass Balances, Dispersion Models, Pollutant Emissions Minimization - Case Study.

Unit 12

Prediction and Assessment of Impacts on the Land Environment – Soil & Geological properties, Universal Soil Loss equation, mitigation measures.

Unit 13

Risk Assessment – Hazard Identification, Effect Assessment, Risk characterization, Risk Reduction.

Unit 14

Attributes, Standards and Value functions, public participation in EIA. Environmental Management Plan (EMP) and Disaster Management Plan (DMP).

Unit 15

EIA Case Studies – Thermal Power Plant, Mining, Fertilizer, Construction Projects, Airport, Water and Wastewater Treatment Plants.

References

1. Kormandy, (1996), "Concepts of Ecology", 4th Edition, Prentice Hall publication, New Jersey.
2. Odum, (1974), "Fundamentals of Ecology", 3rd Edition, W.B. Saunders & CO, NBF.
3. Krebs J., (2008), "Ecology – The Experimental Analysis of Distribution and Abundance", 6th Edition, Perason International.
4. Hall C.A.S., and Day J.W. (1977), "Ecosystem Modeling in Theory and Practice: An Introduction with Case Histories", John Willey.
5. Canter L., (1995), "Environmental Impact Assessment", 2nd Edition, McGraw Hill Higher Education.
6. Weathern, P., (1982), "Environmental Impact Assessment – Theory and Practice", Unwin Hyman, London.
7. Jain R.K., Urban L.V., Stacey G.S., (1981), "Environmental Impact Analysis – A New Dimension in Decision Making", 2nd Edition, Van Nostrand Reinhold Co.
8. Clark B.C., Bisett and Tomilson P, (1985), "Perspective on Environmental Impact Assessment", Allied Publishers.
9. Charles, H., (2011), "Environmental Impact Assessment", 1st Edition, CRC Press.

10. Rau and Wooten, (1981). "Environmental Impact Assessment Handbook", McGraw Hill.

Course outcomes (CO):

1. Students will be able to understand structure and function of ecosystem in conservation of different kind of Environmental system.
2. Students will be able to understand principles, modeling and application of ecological engineering.
3. Students will have adequate knowledge of scope and contents, methodologies and techniques of Environmental Impact Assessment.
4. Students will have understanding of prediction and assessment of impacts on the surface water environment, air environment and land environment.
5. Students will have understanding of basics of risk characterisation and risk reduction.
6. Students will have sufficient knowledge of case studies related to Environmental Impact Assessment.

Table 1: To establish the correlation between COs & POs

No. of Curse Outcome (CO)	Course Outcome
PCE42C03.1	Students will be able to understand structure and function of ecosystem in conservation of different kind of Environmental system.
PCE42C03.2	Students will be able to understand principles, modeling and application of ecological engineering.
PCE42C03.3	Students will have adequate knowledge of scope and contents, methodologies and techniques of Environmental Impact Assessment.
PCE42C03.4	Students will have understanding of prediction and assessment of impacts on the surface water environment, air environment and land environment.
PCE42C03.5	Students will have understanding of basics of risk characterisation and risk reduction.
PCE42C03.6	Students will have sufficient knowledge of case studies related to Environmental Impact Assessment.

Table-2: Correlation between COs & POs

Slight (LOW): 1 Moderate (MEDIUM): 2 Substantial (HIGH): 3 and

for NO CORELATION: '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE42C01.1	3	2	3	2	3	3
PCE42C01.2	3	2	3	3	2	2
PCE42C01.3	3	2	3	3	2	2
PCE42C01.4	3	2	3	2	3	3
PCE42C01.5	3	2	3	3	3	2
PCE42C01.6	3	2	3	3	2	2
Total	**18**	**12**	**18**	**16**	**15**	**14**
Average	**3**	**2**	**3**	**2.67**	**2.5**	**2.33**
Equivalent Avg. Attainment	**3**	**2**	**3**	**3**	**3**	**2**

Table 3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE42C03.1	3	3
PCE42C03.2	3	3
PCE42C03.3	3	3
PCE42C03.4	3	3
PCE42C03.5	3	3
PCE42C03.6	3	3
Total	18	18
Average	3	3
Equivalent Avg. Attainment	**3**	**3**

WATER POLLUTION LABORATORY-II
(PCE42P01)

Total Credit: 02
Contact Periods: 03 (0L+0T+3P)

Courses Objective:

1. To gain knowledge about the determination technique of Arsenic and fluoride concentrations in water samples
2. To determine the optimum coagulant dose for a water and wastewater sample using Jar test
3. To obtain concentration of various metal present in water samples.
4. To understand the importance of water quality Index (WQI) and its application
5. To measure various water pollutants using colorimetry method.
6. To measure various water quality parameter using Gas chromatography.

Course Content:

1. Determination of Arsenic and fluoride concentrations in water samples.
2. Determination of optimum coagulant dose by Jar test for any water/wastewater sample
3. Determination of metal concentrations (Eg. iron, chromium, cadmium, or other heavy metals) in water and wastewater sample
4. Determination of water quality Index (WQI) of surface and groundwater sources using WQI methods like CCME WQI, NSF WQI, Bhargava WQI or any other well-known WQI methods
5. Application of colorimetry for determination of concentration of several water pollutants (Eg, synthetic dyes in single and binary systems).
6. Application of Gas chromatography for water and wastewater sample analysis

Course Outcome:

1. Students will be able to analyse Arsenic and fluoride concentrations in water samples.
2. Students will be able to determine alum required to coagulate a given sample of raw water using Jar test
3. Students will be able to determine concentration of various metal present in water samples.
4. Students will be able determine the water quality Index (WQI)
5. Students will be able to determine various water quality parameters using Gas chromatography.

6. Students will be able to determine the concentration of various water pollutants using colorimetry method.

Table 1: To establish the correlation between COs & POs

No. of Curse Outcome (CO)	Course Outcome
PCE42P01.1	Students will be able to analyse Arsenic and fluoride concentrations in water samples.
PCE42P01.2	Students will be able to determine alum required to coagulate a given sample of raw water using Jar test
PCE42P01.3	Students will be able to determine concentration of various metal present in water samples.
PCE42P01.4	Students will be able to determine concentration of various metal present in water samples.
PCE42P01.5	Students will be able to determine various water quality parameter using Gas chromatography.
PCE42P01.6	Students will be able to determine various water quality parameter using colorimetry method.

Table-2: Correlation between COs & POs

Slight (LOW): 1 Moderate (MEDIUM): 2 Substantial (HIGH): 3 and for NO CORELATION: '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE41P02.1	3	3	3	2	2	3
PCE41P02.2	3	3	3	2	2	3
PCE41P02.3	3	3	3	2	3	3
PCE41P02.4	3	3	2	2	3	2
PCE41P02.5	3	3	3	3	2	2
PCE41P02.6	2	3	3	3	3	2
Total	17	18	17	14	15	15
Average	2.83	3	2.83	2.33	2.5	2.5
Equivalent Avg. Attainment	**3**	**3**	**3**	**2**	**3**	**3**

Table 3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE42P01.1	3	3
PCE42P01.2	3	3
PCE42P01.3	3	3
PCE42P01.4	3	3
PCE42P01.5	3	3
PCE42P01.6	3	3
Total	18	18
Average	3	3
Equivalent Avg. Attainment	**3**	**3**

AIR POLLUTION LABORATORY
(PCE42P02)

Total Credit: 02
Contact Periods: 03 (0L+0T+3P)

Courses Objective:

1. To measure suspended particulate matter (SPM) concentration in air.
2. To analyse the vehicular emission.
3. To grasp the significance of ambient air quality monitoring.
4. To obtain SO_X and NO_X concentration in air.
5. To measure of Sound Pressure Level and noise pollution by sound meter.
6. To understand the nature and scope of environmental education with regards to Field survey Brick kiln sites, CNG sites.

Course Content:

1. Measurement of suspended particulate matter (SPM) concentration in air.
2. Measurement of vehicular emission
3. Ambient air quality monitoring.
4. Determination of SO_X and NO_X concentration in air
5. Measurement of Sound Pressure Level and noise pollution by sound meter.
6. Field survey Brick kiln sites, CNG sites.

Course Outcome:

1. Students will be able to determine suspended particulate matter (SPM) concentration in air.
2. Students will be able to determine measure vehicular emission.
3. Students will be able to grasp the significance of Ambient air quality monitoring.
4. Students will be able to determine SO_X and NO_X concentration in air.
5. Students will be able to determine Sound Pressure Level and noise pollution by sound meter.
6. Students will be able to understand how to control air pollution at Brick kiln sites, CNG sites.

Table 1: To establish the correlation between COs & POs

No. of Curse Outcome (CO)	Course Outcome
PCE42P02.1	Students will be able to determine suspended particulate matter (SPM) concentration in air.
PCE42P02.2	Students will be able to determine measure vehicular emission.
PCE42P02.3	Students will be able to grasp the significance of Ambient air quality monitoring.
PCE42P02.4	Students will be able to determine SO_X and NO_X concentration in air.
PCE42P02.5	Students will be able to determine Sound Pressure Level and noise pollution by sound meter.
PCE42P02.6	Students will be able to understand how to control air pollution at Brick kiln sites, CNG sites.

Table-2: Correlation between COs & POs

Slight (LOW): 1 Moderate (MEDIUM): 2 Substantial (HIGH): 3 and

for NO CORELATION: '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE42P02.1	3	2	3	3	3	3
PCE42P02.2	3	3	3	2	3	3
PCE42P02.3	3	3	3	3	2	2
PCE42P02.4	2	3	3	2	3	2
PCE42P02.5	3	3	2	2	2	2
PCE42P02.6	3	3	3	2	3	2
Total	**17**	**17**	**17**	**14**	**16**	**14**
Average	**2.83**	**2.83**	**2.83**	**2.33**	**2.67**	**2.33**
Equivalent Avg. Attainment	**3**	**3**	**3**	**2**	**3**	**2**

Table 3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
PCE42P01.1	2	2
PCE42P01.2	2	2
PCE42P01.3	2	2
PCE42P01.4	2	2
PCE42P01.5	2	2
PCE42P01.6	2	2
Total	12	12
Average	2	2
Equivalent Avg. Attainment	**2**	**2**

COMPREHENSIVE VIVA-VOCE
(PCE42P03)

Total Credit: 02
Contact Periods: 00 (0L+0T+0P)

Each student will be assessed based on the overall performance in the subject matters related to Environmental Engineering and their ability to communicate effectively.

PROJECT PRELIMINARY
(PCE42P04)

Total Credit: 03
Contact Periods: 06 (0L+0T+6P)

The Project preliminary will involve the introduction for each student's individual thesis work by their own with the help of supervisor. A research problem needs to be identified after through literature review and finding the research gap. Some preliminary findings and results are to be presented preferably with literature review in the form of thesis where detail reports/photographic records / drawings / computer printout need to be incorporated. Presentation in seminar will be encouraged.

Elective Pool

(Selected Electives will be offered in each semester based on available faculties)

Sl. No.	Subject	Credit	Class Hours per Week	Marks
1	Remote Sensing and GIS in Environmental Engineering	4	4	100
2	Hydraulics & Water Resources Engineering	4	4	100
3	Water Distribution and Wastewater Collection System Design	4	4	100
4	Air and Water Quality Modelling	4	4	100
5	Environmental Planning and Management	4	4	100
6	Industrial Pollution Control	4	4	100
7	Advanced Environmental Biotechnology	4	4	100
8	Management of Water Resources	4	4	100
9	Renewable Energy System	4	4	100
10	Geo-environmental Engineering	4	4	100

REMOTE SENSING AND GIS IN ENVIRONMENTAL ENGINEERING

Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses Objective:

1. To make the students conversant with basic of GIS and its general application in various fields.
2. To have adequate knowledge on Type of data and information handled in GIS.
3. To have adequate knowledge on various GIS analysis operations with vector data.
4. To have adequate knowledge on various GIS analysis operations with Raster data.
5. To understand Remote sensing and its basic along with its application in Environmental Engineering.
6. To have practical knowledge about handing geo-spatial data.

Course Content:

Unit 1

Introduction/Fundamental to GIS (History of GIS, Early developments in GIS, components of GIS, Applications of GIS)

Unit 2

Spatial Data Modelling (Representation of spatial data, Raster & vector data model, TIN & DEM), Geo-referencing and Projection (Coordinate System, Map Projection, Transformation, Geo-referencing),Map and Map Scales (Introduction to Maps, Map Scales, Types of Maps, Map and Globe)

Unit 3

Data Base Management system (Data Storage, Database Structure Models, GIS Data File Management), Spatial data (Primary data, Secondary data, Data pre-processing)
Practical S -2

Unit 4

Data Analysis (Vector operation & analysis, Raster operation & analysis, Network Analysis), Interpolation Technique (Global Methods of Interpolation, Local Methods of Interpolation) Practical S -3

Unit 5

Cartographic Principles and Design (Introduction, Map layout, Toposheet, component of Map), GPS, Introduction to Remote sensing and its application

References

1. Burrough P A., (1986), "GIS for Land Resource Assessment", Oxford University Press, U.K.
2. Star J.L., and Estes J.E., (1990). "Geographic Information Systems; An Introduction". Prentice Hall Publications.
3. Laurini R. and Thompson D., (1992), "Fundamentals of Spatial Information Systems", 1st Edition, Academic Press.
4. Mishra H.C., (1997), "GIS Handbook", GIS India, ShanthiNivas, Hyderabad.
5. Anji Reddy, (2012), "Textbook of Remote Sensing and GIS", 4th Edition, B.S. Publications, Hyderabad.
6. Floyd F. Sabins, (1996) "Remote Sensing - Principles and Interpretations", 3rd Edition, W.H. Freeman & Co.
7. Michael N. Demas. (2000), "Fundamentals of GIS", John Wiley & Sons, Inc.

Course Outcome:

1. Students will be able to understand basics about GIS and RS
2. Students will be able to understand the practical application of GIS & RS in Environmental Engineering.
3. Students will be able to analysis and visualize their own data sets in GIS domain
4. Students will be able to download and process various data obtained from various RS platform
5. Students will be able to use the knowledge to solve practical real life problem and help in planning & management.

Table 1: To establish the correlation between COs & Pos

No. of Curse Outcome (CO)	Course Outcome
CO-1	Students will be able to understand basics about GIS and RS
CO-2	Students will be able to understand the practical application of GIS & RS in Environmental Engineering.
CO-3	Students will be able to analysis and visualize their own data sets in GIS domain
CO-4	Students will be able to download and process various data obtained from various RS platform
CO-5	Students will be able to use the knowledge to solve practical real life problem and help in planning & management.

Table-2: Correlation between COs & POs

Slight (LOW): 1 Moderate (MEDIUM): 2 Substantial (HIGH): 3 and

for NO CORELATION: '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO-1	3	3	3	3	2	2
CO-2	3	3	3	3	3	2
CO-3	3	3	3	2	3	3
CO-4	3	3	3	3	2	2
CO-5	3	3	3	2	2	3
Total	**15**	**15**	**15**	**13**	**12**	**12**
Average	**3**	**3**	**3**	**2.6**	**2.4**	**2.4**
Equivalent Avg. Attainment	**3**	**3**	**3**	**3**	**2**	**2**

Table 3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
CO-1	3	2
CO-2	3	2
CO-3	3	2
CO-4	3	2
CO-5	3	2
Total	18	12
Average	3	2
Equivalent Avg. Attainment	**3**	**2**

HYDRAULICS & WATER RESOURCES ENGINEERING

Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses objective:

1. To understand the basic concepts of surface water hydrology.
2. To study the design principles of wastewater collection systems.
3. To study the hydraulics of ground water & groundwater hydrology.
4. To have adequate knowledge on balancing of reservoir capacity.
5. To have adequate knowledge on open channel flow and drainage system.
6. To have adequate knowledge on free surface seepage flow in earth dams.

Course content:

Unit 1

Surface water hydrology: Basic concepts of hydrology; structure and composition of atmosphere, air mass, cold and warm fronts; atmospheric temperature and it variations; vapour pressure and relative humidity; evaporation and evapo-transpiration; types and forms of precipitation; measurement of precipitation and other atmospheric parameters.

Unit 2

Water supply and distribution of water, collection of waste water: Design principles of wastewater collection systems: separate, combined and semi-combined sewers; Estimation of dry weather flows; Design of sewer networks, Sewer pipe hydraulics: sizing of pipes and design.

Unit 3

Hydraulics of ground water & groundwater hydrology: The continuum approach to transport in subsurface hydrology; Darcy's law and its generalization; flow through saturated and unsaturated porous formations; well hydraulics, analysis of pumping test data, ground water recharge.

Unit 4

Balancing of reservoir capacity.

Unit 5

Pipe flow and pipe networks: Continuity Equation, Energy Equation, Hydraulic and Energy Grade Lines, Head Loss Models: Darcy-Weisbach and Moody Chart, Hazen-Williams, etc. Conduit Systems, Branching Pipes, Pipe network design.

Unit 6

Open channel flow and drainage system.

Unit 7

Pneumatic systems.

Unit 8

Pumping stations.

Unit 9

Free surface seepage flow in earth dams

References

1. Chow, V.T., Maidment, D.R., Mays, L.W., (2017), Applied Hydrology, 1st Edition, McGraw Hill Education.
2. Todd, D.K., (2011), Ground Water Hydrology, Third Edition, Wiley India Pvt Ltd.
3. Garg, S. K., (2001), "Water Supply Engineering", Khanna Publication.
4. Garg, S. K., (2005), "Sewage Disposal and Air Pollution Engineering", Khanna Publication.
5. Peavey, H.S., Rowe and Tchobonoglous,G., (2017), "Environmental Engineering", 1st Edition, McGraw Hill.
6. McGhee, T. J., (1991). "Water Supply and Sewerage, 6th Edition, McGraw Hill International.

Course outcome:

1. Students will be able to understand basic concepts of surface water hydrology.
2. Students will be able to understand the design principles of wastewater collection systems.
3. Students will be able to get adequate knowledge on the hydraulics of ground water & groundwater hydrology.
4. Students will be able to understand the balancing of reservoir capacity.
5. Students will be able to get adequate knowledge on open channel flow and drainage system.
6. Students will be able to understand free surface seepage flow in earth dams.

Table 1: To establish the correlation between COs & POs

No. of Curse Outcome (CO)	Course Outcome
CO-1	Students will be able to understand basic concepts of surface water hydrology.
CO-2	Students will be able to understand the design principles of wastewater collection systems.
CO-3	Students will be able to get adequate knowledge on the hydraulics of ground water & groundwater hydrology.
CO-4	Students will be able to understand the balancing of reservoir capacity.
CO-5	Students will be able to get adequate knowledge on open channel flow and drainage system.
CO-6	Students will be able to understand free surface seepage flow in earth dams.

Table-2: Correlation between COs & POs

Slight (LOW): 1 Moderate (MEDIUM): 2 Substantial (HIGH): 3 and

for NO CORELATION: '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO-1	3	3	3	2	2	3
CO-2	3	2	3	3	3	2
CO-3	3	3	3	2	3	3
CO-4	3	2	3	3	2	3
CO-5	3	3	3	3	2	2
CO-6	3	2	3	3	3	2
Total	18	15	18	16	15	15
Average	3	2.5	3	2.67	2.5	2.5
Equivalent Avg. Attainment	**3**	**3**	**3**	**3**	**3**	**3**

Table 3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
CO-1	3	2
CO-2	3	2
CO-3	3	2
CO-4	3	2
CO-5	3	2
CO-6	3	2
Total	18	12
Average	3	2
Equivalent Avg. Attainment	**3**	**2**

WATER DISTRIBUTION AND WASTEWATER COLLECTION SYSTEM DESIGN

Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses objective:

1. To understand the water supply system and its components.
2. To grasp the significance of Design period, Factors affecting water consumption and variation in demand.
3. To understand the design of water distribution network.
4. To understand the design parameters and methods of service reservoirs.
5. To understand the design principles of wastewater collection systems.
6. To understand maintenance of water supply and wastewater systems.

Course content:

Unit 1

Components of water supply systems: Water use and demand estimation, Design period, population data and flow rates for water supply systems, Factors affecting water consumption and variation in demand.

Unit 2

Design of water distribution systems, methods of analysis for optimal distribution network design. Types of reservoirs and design parameters and methods: Design of water pumping stations.

Unit 3

Design principles of wastewater collection systems: separate, combined and semi-combined sewers; Estimation of dry weather flows; Sewer pipe hydraulics: sizing of pipes and design; Manhole chambers and storm water overflows; Pumping stations, screens and inverted screens, Maintenance of water supply and wastewater systems.

References

1. Peavey, H.S., Rowe and Tchobonoglous,G., (2017), “Environmental Engineering”, 1st Edition, McGraw Hill.
2. McGhee, T. J., (1991). “Water Supply and Sewerage, 6th Edition, McGraw Hill International.
3. Garg, S. K., (2001), “Water Supply Engineering”, Khanna Publication.

4. Garg, S. K., (2005), "Sewage Disposal and Air Pollution Engineering", Khanna Publication.

Course outcome:

1. Students will be able to learn about the water supply system and its components.
2. Students will be able to about Design period, Factors affecting water consumption and variation in demand.
3. Students will be able to design water distribution network.
4. Students will be able to design service reservoirs.
5. Students will be able to learn the design principles of wastewater collection systems.
6. Students will be able to understand about maintenance of water supply and wastewater systems.

Table 1: To establish the correlation between COs & POs

No. of Curse Outcome (CO)	Course Outcome
CO-1	Students will be able to learn about the water supply system and its components.
CO-2	Students will be able to about Design period, Factors affecting water consumption and variation in demand.
CO-3	Students will be able to design water distribution network.
CO-4	Students will be able to design service reservoirs.
CO-5	Students will be able to learn the design principles of wastewater collection systems.
CO-6	Students will be able to understand about maintenance of water supply and wastewater systems.

Table-2: Correlation between COs & POs

Slight (LOW): 1 Moderate (MEDIUM): 2 Substantial (HIGH): 3 and for NO CORELATION: '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO-1	2	3	2	2	2	3
CO-2	3	3	3	2	2	3
CO-3	3	3	3	2	2	3
CO-4	3	3	3	2	2	3
CO-5	3	3	3	2	2	3
CO-6	3	3	3	2	2	3
Total	17	18	17	12	12	18
Average	2.83	3.00	2.83	2.00	2.00	3.00
Equivalent Avg. Attainment	**3**	**3**	**3**	**2**	**2**	**3**

Table 3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
CO-1	2	2
CO-2	2	2
CO-3	2	2
CO-4	2	2
CO-5	2	2
CO-6	2	2
Total	12	12
Average	2	2
Equivalent Avg. Attainment	**2**	**2**

AIR AND WATER QUALITY MODELING

Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses objective:

1. To understand the importance of mathematical models for water and air quality management.
2. To understand the cause and effect of surface water quality
3. To assess required level of controls in surface water quality modeling
4. To develop a clear conceptual model to predict ground water contaminants
5. To study about computer-based modeling for surface and ground water quality
6. To understand the ambient air quality standards.

Course content:

Unit 1

Systems Approach: Water and air quality management - Role of mathematical models, systems approach - systems and models - kinds of mathematical models - model development and validation effluent and stream standards, ambient air quality standards.

Unit 2

Surface Water Quality Modeling: Water quality description, various characteristics of water, water quality criteria and standards. Elements of reaction kinetics, spatial and temporal aspects of contaminant transport, transport mechanism-advection, diffusion, dispersion. Historical development of water quality models: rivers and streams water quality modeling river hydrology and flow - low flow analysis - dispersion and mixing - flow, depth, and velocity estuaries - estuarine transport, net estuarian flow, estuary dispersion coefficient; Lakes and impoundments - water quality response to inputs, water quality modeling process- model sensitivity - assessing model performance; Models for dissolved oxygen, pathogens: Streeter - Phelps models.

Unit 3

Air Quality Modeling: Transport and dispersion of air pollutants - Kinetics of air pollutants: Atmospheric advection-diffusion of pollutants; Fick's law of diffusion, wind velocity. wind speed and turbulence: estimating concentrations from point sources, area sources and line sources of pollution; - the Gaussian Equation - determination of dispersion parameters, atmospheric stability, Pasquill-Gifford stability classes; Inversions; Potential temperature gradient, dispersion instrumentation - Atmospheric traces: concentration variation with

averaging time: Air pollution modeling and prediction - Plume behavior; Mixing heights, Plume rise, modeling techniques, modeling for nonreactive pollutants, single source - short term impact: multiple sources and area sources, model performance, accuracy and utilization: computer models. Advanced techniques in air quality modeling: Artificial Neural Networks (ANN), Hybrid modeling approach, Fuzzy logic theory (FLT), and Environmental wind tunnel (physical) models.

Unit 4

Groundwater Quality Modeling: Mass transport of solutes, degradation of organic compounds, application of concepts to predict groundwater contaminant movement. Ground water remediation.

Unit 5

Computer Models: Exposure to computer models for surface water quality, groundwater quality and air quality.

References:

1. Steven C. Chapra, (2008), “Surface Water quality modeling”, The McGraw-Hill Companies, Inc., New York.
2. R.W. Boubel, D.L. Fox, D.B. Turner & A.C. Stern, (2008), "Fundamentals of Air pollution”, 4th Edition, Academic Press, New York.
3. Ralph A. Wurbs, (1995), "Water Management Models - A Guide to Software”, Prentice Hall PTR, Facsimile edition, New Jersey,
4. Thomann, R.V. and Mueller, J.A., (1997), First Edition, Principles of surface water quality modeling and control, Pearson Education India.
5. Barratt, R., Atmospheric Dispersion Modeling, Earthscan Publication Ltd, 2003

Course outcome:

1. Students will be able to understand importance of mathematical models for water and air quality management.
2. Students will be given a broad idea to understand the cause and effect of surface water quality
3. Students will be able to assess required level of controls in surface water quality modeling.
4. Students will be able to develop a clear conceptual model to predict ground water contaminants.

5. Students will be able to understand the ambient air quality standards.
6. Students will be able to aware of various computer-based modeling for surface and ground water quality.

Table 1: To establish the correlation between COs & Pos

No. of Curse Outcome (CO)	Course Outcome
CO-1	Students will be able to understand importance of mathematical models for water and air quality management.
CO-2	Students will be given a broad idea to understand the cause and effect of surface water quality
CO-3	Students will be able to assess required level of controls in surface water quality modeling.
CO-4	Students will be able to develop a clear conceptual model to predict ground water contaminants.
CO-5	Students will be able to understand the ambient air quality standards.
CO-6	Students will be able to aware of various computer-based modeling for surface and ground water quality

Table-2: Correlation between COs & POs

Slight (LOW): 1 Moderate (MEDIUM): 2 Substantial (HIGH): 3 and for NO CORELATION: '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO-1	2	3	2	2	2	3
CO-2	3	3	3	2	2	3
CO-3	3	3	3	2	2	3
CO-4	3	3	3	2	2	3
CO-5	3	3	3	2	2	3
CO-6	3	3	3	2	2	3
Total	17	18	17	12	12	18
Average	2.83	3.00	2.83	2.00	2.00	3.00
Equivalent Avg. Attainment	**3**	**3**	**3**	**2**	**2**	**3**

Table 3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
CO-1	3	3
CO-2	3	3
CO-3	3	3
CO-4	3	3
CO-5	3	3
CO-6	3	3
Total	18	18
Average	3	3
Equivalent Avg. Attainment	**3**	**3**

ENVIRONMENTAL PLANNING AND MANAGEMENT

Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses objective:

1. To understand the basic theory of environment and sustainable development.
2. To study the engineering methodology in planning and its limitations.
3. To study the environmental protection.
4. To have adequate knowledge on environmental impact assessment.
5. To have adequate knowledge on engineering and environmental economics.
6. To have adequate knowledge on total quality management in environmental management and protection.

Course content:

Unit 1

Environment and Sustainable Development - carrying capacity, relationship with quality of life, carrying, indicators of sustainability, sustainability strategies, barriers to sustainability, resource utilization, resource degradation, industrial ecology, socio economic policies for sustainable development and clean development mechanism.

Unit 2

Engineering Methodology in Planning and Its Limitations - carrying capacity based short- and long-term regional planning.

Unit 3

Environmental impact assessment (EIA) - definitions and concepts, rationale and historical development of EIA, sustainable development, initial environmental examination, environmental impact statement, environmental appraisal, environmental impact factors and areas of consideration, measurement of environmental impact, organization, scope and methodologies of EIA, status of EIA in India.

Unit 4

Environmental Protection - Economic development and social welfare consideration in socio economic developmental policies and planning.

Unit 5

Total cost of development and environmental protection cost. Case studies on Regional carrying capacity.

Unit 6

Engineering Economics - Value Engineering, Time Value of Money, Cash Flows, Budgeting and Accounting.

Unit 7

Environmental Economics: Introduction, economic tools for evaluation, Green GDP, Cleaner development mechanisms and their applications.

Unit 8

Environmental Audit - methods, procedure, environmental audit versus accounts audit, compliance audit, methodologies and regulations reporting and case studies, Life cycle assessment; Triple bottom line approach.

Unit 9

Total Quality Management in Environmental Management and Protection - ISO 9000, 14000 and 18000 series of standards.

Referencs:

1. Lohani B.N and North A.M., (1984)., "Environmental Quality Management", South Asian Publishers, New Delhi.
2. Chanlett E.T., (1979), “Environmental Protection”, McGraw Hill Publication, New York.
3. Danoy G.E., and Warner R.F., (1989), "Planning and Design of Engineering Systems", First Edition, CRC press, Unwin Hyman Publications.
4. MOEF, Government of India, "Carrying Capacity Based Developmental Planning Studies for the National Capital Region", 1995-96.
5. NEERI, Nagpur, Annual Reports 1995 & 1996.
6. UNEP/UNDP (2012) "Environmental Sustainable Development".

Course outcome:

1. Students will be able to understand the theory of environment and sustainable development.
2. Students will be able to understand the engineering methodology in planning and its limitations.
3. Students will be able to get adequate knowledge on environmental protection.
4. Students will be able to assess the environmental impact.

5. Students will be able to get adequate knowledge on engineering and environmental economics.
6. Students will be able to understand total quality management in environmental management and protection.

Table 1: To establish the correlation between COs & POs

No. of Curse Outcome (CO)	Course Outcome
CO-1	Students will be able to understand the theory of environment and sustainable development.
CO-2	Students will be able to understand the engineering methodology in planning and its limitations.
CO-3	Students will be able to get adequate knowledge on environmental protection.
CO-4	Students will be able to assess the environmental impact.
CO-5	Students will be able to get adequate knowledge on engineering and environmental economics.
CO-6	Students will be able to understand total quality management in environmental management and protection.

Table-2: Correlation between COs & POs

Slight (LOW): 1 Moderate (MEDIUM): 2 Substantial (HIGH): 3 and for NO CORELATION: '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO-1	3	3	3	2	3	3
CO-2	3	3	3	2	3	3
CO-3	3	3	3	2	3	3
CO-4	3	3	3	2	3	3
CO-5	2	3	3	2	3	3
CO-6	3	3	3	2	3	3
Total	17	18	18	12	18	18
Average	2.83	3.00	3.00	2.00	3.00	3.00
Equivalent Avg. Attainment	**3**	**3**	**3**	**2**	**3**	**3**

Table 3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
CO-1	3	2
CO-2	3	2
CO-3	3	2
CO-4	3	2
CO-5	3	2
CO-6	3	2
Total	18	12
Average	3	2
Equivalent Avg. Attainment	**3**	**2**

INDUSTRIAL POLLUTION CONTROL

Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Course objectives:

1. To have sufficient knowledge on Engineering ethics, environment and Ecological.
2. To have sufficient knowledge on fundamentals of EIA and ESA.
3. To have better understanding of Industrial Air pollution management.
4. To have adequate knowledge on Wastewater treatment processes.
5. To have understanding of advanced wastewater treatment processes.
6. To have sufficient knowledge on Hazardous Waste Management.

Course content:

Unit 1

Engineering ethics and environment. Ecological systems and pollution. Fundamental definitions of pollution parameters, Standards and legislation, EIA and ESA. Air and water pollution management through waste minimization.

Unit 2

Industrial Air pollution management - air pollution meteorology (Generation, transportation and dispersion of air pollutants). Outlines of industrial air pollution control. Selection, design and performance analysis of air pollution control equipment.

Unit 3

Industrial Water pollution management - Wastewater treatment processes and advanced wastewater treatment processes.

Unit 4

Hazardous Waste Management - Sources, Classification, Regulations for Hazardous Waste Management, Waste Minimization and Resource Recovery – Approaches, Development of a Waste Tracking, Treatment of hazardous waste, Thermal treatment, Soil contamination and site remediation, monitoring of disposal sites.

References:

1. Jr. W. Eckenfelder (2007), “Industrial Waste Water Pollution Control”, McGrawHill Exclusive (CBS).
2. Pichtel J., (2014), “Waste Management Practices: Municipal, Hazardous and Industrial”, 2nd Edition, CRC Press.

3. Bhatia, S. C., (2007), "Solid and Hazardous Waste Management", 1st Edition, Atlantic Publishers & Distributors.
4. Rao, C.S., (2018), "Environmental Pollution Control Engineering", 3rd Edition, New Age International Publishers.
5. De Nevers, N., (2000), "Air Pollution Control Engineering", 2nd Edition, McGraw-Hill Education.
6. Nemerow, N. L., (1978), "Industrial water pollution: Origin, characteristics and treatment", Addison-Wesley Educational Publishers Inc.

Course outcomes (CO):

1. Students will be able to understand fundamentals of Engineering ethics, environment and Ecological.
2. Students will have knowledge on EIA and ESA.
3. Students will have adequate knowledge Industrial Air pollution management.
4. Students will have understanding of designing Wastewater treatment processes.
5. Students will have understanding of designing of advance Wastewater treatment processes.
6. Students will have sufficient knowledge on Hazardous Waste Management.

Table 1: To establish the correlation between COs & POs

No. of Curse Outcome (CO)	Course Outcome
CO-1	Students will be able to understand fundamentals of Engineering ethics, environment and Ecological.
CO-2	Students will have knowledge on EIA and ESA.
CO-3	Students will have adequate knowledge Industrial Air pollution management.
CO-4	Students will have understanding of designing Wastewater treatment processes.
CO-5	Students will have understanding of designing of advance Wastewater treatment processes.
CO-6	Students will have sufficient knowledge on Hazardous Waste Management.

Table-2: Correlation between COs & POs

Slight (LOW): 1 Moderate (MEDIUM): 2 Substantial (HIGH): 3 and for NO CORELATION: '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO-1	2	1	1	2	3	3
CO-2	2	1	1	3	2	3
CO-3	3	3	3	2	3	2
CO-4	3	3	3	3	2	3
CO-5	3	3	3	3	2	2
CO-6	3	3	3	2	3	2
Total	**16**	**14**	**14**	**15**	**15**	**16**
Average	**2.67**	**2.33**	**2.33**	**2.5**	**2.5**	**2.67**
Equivalent Avg. Attainment	**3**	**2**	**2**	**3**	**3**	**3**

Table 3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
CO-1	3	3
CO-2	3	3
CO-3	3	3
CO-4	3	3
CO-5	3	3
CO-6	3	3
Total	18	18
Average	3	3
Equivalent Avg. Attainment	**3**	**3**

ADVANCED ENVIRONMENTAL BIOTECHNOLOGY

Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Course objectives:

1. To have sufficient knowledge on fundamentals of Environment and Microbiology.
2. To have adequate knowledge on Microbial Genetics, metabolism, Health and hygiene, interactions and Toxicology.
3. To have better understanding on microbiology of Suspended Growth Process.
4. To have better understanding on microbiology of Attached Growth Process.
5. To have understanding of Bioremediation of Hazardous contaminants and emerging contaminants, Environmental sustainability.
6. To have sufficient knowledge on Environmental sustainability, Bio-fertilizers and Biopesticide.

Course content:

Unit 1

Review of concepts of Environment and Microbiology, Microbial Ecology, Microbial energetics, Microbial kinetics.

Unit 2

Concept of Microbial Genetics, Microbial metabolism, Microbiology of Health and hygiene, Microbial interactions, Microbial Toxicology, Degradation of Xenobiotics.

Unit 3

Microbiology of wastewater: Suspended Growth Process- Aerobic and Anaerobic, Biofilm kinetics, Attached Growth Process- Aerobic and Anaerobic, Biological nutrient removal, Facultative Processes.

Unit 4

Biodegradability, Bioremediation: Engineering strategies for bioremediation, Microbial Remediation of Solid-wastes, Bioremediation of Hazardous contaminants and emerging contaminants, Environmental sustainability, Bio-fertilizers and Biopesticide.

References:

1. Metcalf and Eddy Inc., (2012), "Wastewater Engineering – Treatment and Reuse", 4th Edition, Tata McGraw Hill Publishing Co. Ltd., New Delhi.
2. Odum, (1974), "Fundamentals of Ecology", 3rd Edition, W.B. Saunders & CO, NBF.

3. R.L. Smith, (2000), "Ecology and field biology", 6th Edition, Benjamin Cummings.
4. Manahan S.E., (2009), "Principals of Environmental chemistry", 9th Edition, CRC press.
5. R.B. Philip, (1995), "Environmental hazards & human health", Lewis Publisher, Boca Raton, FL.
6. Uppadahay A., Uppadahay K., and Nath N. "Principles of Biophysical chemistry", 7th Edition, Principles and Techniques of Biochemistry and Molecular Biology.
7. Pelczar M.J, Chan ECS, Krieg, NR(2004) "Textbook of Microbiology" 5th edition Tata McGraw Hill Publishing Co. Ltd., New Delhi.

Course outcomes (CO):

1. Students will be able to understand fundamentals of Environment and Microbiology.
2. Students will have knowledge on Microbial Genetics, metabolism, Health and hygiene, interactions and Toxicology.
3. Students will have adequate knowledge on microbiology of Suspended Growth Process.
4. Students will have adequate knowledge on microbiology of Attached Growth Process.
5. Students will have understanding of Bioremediation of Hazardous contaminants and emerging contaminants, Environmental sustainability.
6. Students will have sufficient knowledge on Environmental sustainability, Bio-fertilizers and Biopesticide.

Table 1: To establish the correlation between COs & POs

No. of Curse Outcome (CO)	Course Outcome
CO-1	Students will be able to understand fundamentals of Environment and Microbiology.
CO-2	Students will have knowledge on Microbial Genetics, metabolism, Health and hygiene, interactions and Toxicology.
CO-3	Students will have adequate knowledge on microbiology of Suspended Growth Process.
CO-4	Students will have adequate knowledge on microbiology of Attached Growth Process.
CO-5	Students will have understanding of Bioremediation of Hazardous contaminants and emerging contaminants, Environmental sustainability.
CO-6	Students will have sufficient knowledge on Environmental sustainability, Bio-fertilizers and Biopesticide.

Table-2: Correlation between COs & POs

Slight (LOW): 1 Moderate (MEDIUM): 2 Substantial (HIGH): 3 and for NO CORELATION: '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO-1	2	1	1	2	3	3
CO-2	3	3	1	3	2	3
CO-3	3	3	3	2	3	2
CO-4	3	3	3	3	2	3
CO-5	3	3	3	3	2	2
CO-6	2	3	2	2	3	2
Total	**16**	**16**	**13**	**15**	**15**	**16**
Average	**2.67**	**2.67**	**2.17**	**2.5**	**2.5**	**2.67**
Equivalent Avg. Attainment	**3**	**3**	**2**	**3**	**3**	**3**

Table 3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
CO-1	3	3
CO-2	3	3
CO-3	3	3
CO-4	3	3
CO-5	3	3
CO-6	3	3
Total	18	18
Average	3	3
Equivalent Avg. Attainment	**3**	**3**

RENEWABLE ENERGY SYSTEM

Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses Objective:

1. To impart the fundamental concepts of new and renewable energy systems.
2. To make quantitative judgments and perform computations of the different subsystems of solar energy systems.
3. To learn about the different technologies available in location selection, resource assessment and conversion of wind energy.
4. To provide the knowledge on the fundamentals of dams and hydropower generation
5. To describe the principles and technical solutions for different wave power concepts and use this knowledge to evaluate different wave power systems from technical, environmental and societal aspects.
6. To use numerical, analytical, and experimental tools to model and optimize the management of renewable energy system based on the concept of energy audit and economy of the same system.

Course Content:

Unit-1
FUNDAMENTAL CONCEPTS:
Energy Scenario: Classification of Energy Sources, Energy resources (Conventional and nonconventional), Energy needs of India, and energy consumption patterns, Worldwide Potentials of these sources, Energy efficiency and energy security. Energy and its environmental impacts, Distributed generation, Energy storage and hybrid system configurations: Energy storage, Battery – types, equivalent, circuit, performance characteristics, battery design, charging and charge regulators, Battery management. Flywheel-energy relations, Location selection studies.

Unit-2
SOLAR ENERGY SYSTEMS:
Solar thermal Systems: Types of collectors, Collection systems, efficiency calculations, applications. Photo voltaic (PV) technology: Present status, solar cells, cell technologies, characteristics of PV systems, equivalent circuit, array design, building integrated PV system, its components, sizing, and economics, Peak power operation. Standalone and grid interactive systems.

Unit-3

WIND ENERGY CONVERTERS:

Wind resource assessment, Wind speed and power relation, power extracted from wind, wind distribution and wind speed predictions. Wind power systems: classification, system components, Types of Turbines, Turbine rating. Choice of generators, turbine rating, electrical load matching, Variable speed operation, maximum power operation, control systems, system design features, stand alone and grid connected operation.

Unit-4

DAMS AND HYDROPOWER PLANT:

Dam break analysis, Runs Test, Classification of Dams, Gravity and Arch Dams, Design and Management, Factor of Safety Analysis of Dams, Risk and Reliability Analysis, Introduction to hydropower, types of hydropower, location selection studies, penstock, turbine and generator design and optimization, microturbines, scheduling concepts.

Unit-5

WAVE ENERGY CONVERTERS:

Ocean energy resources, Ocean energy routes, Classification, Ocean waves: formation, characterizations, wave climate, energy content, resources and measurement. Ocean thermal energy conversion, Wave energy conversion, Design of Power Takeoff, Mooring Structure, Hydraulic Circuits, Numerical Modelling of Wave Energy Converters. Tidal energy conversion.

Unit-6

AUDIT AND MANAGEMENT OF RENEWABLE ENERGY SYSTEMS:

Energy Audit, Types of Audit, Vulnerability Assessment of Renewable Energy Systems, Application of Multi Criteria Decision Making Tools on Renewable Energy Systems, GIS in Renewable Energy, Reliability and Risk Analysis, Levelized cost of electricity.

References:

1. Renewable Energy System Design, Ziyad Salameh, Academic Press, 2014, 1st Edition.
2. Fundamentals of Renewable Energy Systems, D. Mukherjee and S. Chakrabarti, New Age International, 2004, 1st Esition.
3. Solar Energy Fundamentals and Modeling Techniques, Z.Sen, Springer London, 2010, 1st Edition.
4. Solar Energy for Beginners: The Complete Guide to Solar Power Systems, Panels & Cells, Catherine Gregory, CreateSpace Independent Publishing Platform, 2015, 1st Edition.

5. Wind energy: Theory and Practice, Siraj Ahmed, Prentice Hall India Pvt., Limited, 2015, 3rd Edition.
6. Wave Energy Conversion, John Brooke, Elsevier Science, 2003, 1st Edition.
7. Numerical Modelling of Wave Energy Converters, Matt Folley, Academic Press, 2016, 1st Edition.
8. Energy Management, Audit and Conservation, Barun Kumar De, Vrinda Publications, 2010, 2nd Edition.

Course Outcome:

1. Student will learn about the basics, types, conversion mechanisms of new and renewable energy systems.
2. Student will be able to design solar based power farms for maximum conversion of available solar energy under minimum cost.
3. Student will become familiar about the various technologies available in location selection, resource assessment and conversion of wind energy potential.
4. Student will be acquainted about the fundamentals of dams and hydropower generation and related analytic tools and techniques.
5. Student will be conversant with the principles and technical solutions for different wave power converters and it applications for maximum utilization of available wave energy potential.
6. Student will be able to apply the numerical, analytical, and experimental tools to audit and manage any new and renewable energy systems for maximum utilization of the potential.

Table 1: To establish the correlation between COs & POs

No. of Curse Outcome (CO)	Course Outcome
CO-1	Student will learn about the basics, types, conversion mechanisms of new and renewable energy systems.
CO-2	Student will be able to design solar based power farms for maximum conversion of available solar energy under minimum cost.
CO-3	Student will become familiar about the various technologies available in location selection, resource assessment and conversion of wind energy potential.
CO-4	Student will be acquainted about the fundamentals of dams and hydropower generation and related analytic tools and techniques.
CO-5	Student will be conversant with the principles and technical solutions for different wave power converters and it applications for maximum utilization of available wave energy potential.
CO-6	Student will be able to apply the numerical, analytical, and experimental tools to audit and manage any new and renewable energy systems for maximum utilization of the potential.

Table-2: Correlation between COs & POs

Slight (LOW): 1 Moderate (MEDIUM): 2 Substantial (HIGH): 3 and for NO CORELATION: '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO-1	3	2	3	2	2	2
CO-2	3	2	3	2	2	2
CO-3	3	2	3	2	2	2
CO-4	3	2	3	2	2	2
CO-5	3	2	3	2	2	2
CO-6	3	2	3	2	2	2
Total	18	12	18	12	12	12
Average	3	2	3	2	2	2
Equivalent Avg. Attainment	**3**	**2**	**3**	**2**	**2**	**2**

Table 3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
CO-1	3	3
CO-2	3	3
CO-3	3	3
CO-4	3	3
CO-5	3	3
CO-6	3	3
Total	18	18
Average	3	3
Equivalent Avg. Attainment	**3**	**3**

MANAGEMENT OF WATER RESOURCES

Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Courses Objective:

1. To impart knowledge about the planning and management of water resources.
2. To introduce the concepts of watershed management, integrated water resources management, environmental interaction of water resources and policies/framework related to water resources.
3. To enable student to understand the different components of water resources and their management

Course content:

Unit- 1

Management of hydrological data, Linear Programming and its application in water resources development, Inventory control.

Unit -2

Analysis of risk and uncertainties, Dynamics programming Statistical decision model, Water policies and institutional aspects of management of water resources.

Unit -3

Hierarchical modeling of water resources development, Management of watersheds and water quality.

Unit -4

Reservoir & stream flow routing, probability, risk and uncertainty analysis.

Unit – 5

Urban water supply planning/management, cost-benefit analysis in water resources planning, planning of watersheds

Watershed behaviour and conservation practices, trans-boundary water resources.

Unit – 6

National water policy, water withdrawals & uses, trans-boundary water resources.

References:

1. Water Management, Warren Viessman Jr. and Claire Welty, New York : Harper & Row, 1985. 1st Edition.
2. Water Resources Engineering, Larry W. Mays, Wiley Global Education US, 2019, 3rd Edition.
3. Water Resources Engineering, Ralph A. Wurbs and Wesley P. James, Pearson, 2001, 1st Edition.
4. Water Resources Systems, Planning & Management, S. K. Jain & V. P. Singh, Elsevier Science, 2003, 1st Edition.
5. Modeling Water qualities and Management, Asit K. Biswas, McGraw-Hill Professional, 1997, 1st Edition.
6. Hierarchical Analysis of Water Resources System, Y.Y. Haimes, McGraw Hill Higher Education, 1977, 1st Edition.
7. Waste Water Engineering Treatment and Reuse, Matfalf / Eddy, McGraw-Hill Education (India) Pvt Limited, 2002, 4th Edition.
8. Sustainable water Management Solutions for Large Cities, Dragar A, Savic, Mignel A, International Association of Hydrological Science, 2005, 1st Edition.

Course outcome:

1. Students will be able to identify different problems related to water resources planning, management and development.
2. Students will be able to describe various concept and problems of water related issues.
3. Students will be able to identify the risk and uncertainties of water related issues
4. Students will be able to do the cost-benefit analysis in water resources planning
5. Students will be able to do the urban water supply planning/management, cost-benefit analysis in water resources planning, planning of watersheds.
6. Students will be able to gain knowledge about the national water policy.

Table 1: To establish the correlation between COs & POs

No. of Curse Outcome (CO)	Course Outcome
CO-1	Students will be able to identify different problems related to water resources planning, management and development
CO-2	Students will be able to describe various concept and problems of water related issues
CO-3	Students will be able to identify the risk and uncertainties of water related issues
CO-4	Students will be able to do the cost-benefit analysis in water resources planning
CO-5	Students will be able to do the urban water supply planning/management, cost-benefit analysis in water resources planning, planning of watersheds.

Table-2: Correlation between COs & Pos Slight (LOW): 1 Moderate (MEDIUM): 2 Substantial (HIGH): 3 and for NO CORELATION: '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO-1	3	2	3	3	3	3
CO-2	3	2	3	3	3	3
CO-3	3	2	3	3	3	3
CO-4	3	3	3	3	3	3
CO-5	3	3	3	3	3	3
Total	15	12	15	15	15	15
Average	3	2.4	3	3	3	3
Equivalent Avg. Attainment	**3**	**2**	**3**	**3**	**3**	**3**

Table 3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
CO-1	3	3
CO-2	3	3
CO-3	3	2
CO-4	3	2
CO-5	3	2
Total	15	12
Average	3	2.4
Equivalent Avg. Attainment	**3**	**2**

GEOENVIRONMENTAL ENGINEERING

Total Credit: 04
Contact Periods: 04 (3L+1T+0P)

Course objectives:

1. To have sufficient knowledge on fundamentals of Geoenvironmental Engineering.
2. To have adequate knowledge on planning and design of MSW and Hazardous waste Landfills.
3. To have better understanding on planning and design of slurry ponds - ash ponds and tailing ponds.
4. To have better understanding on subsurface contamination.
5. To have understanding of geotechnical reuse of waste.

Course content:

Unit 1
Concepts and principles of Geoenvironmental Engineering.
Unit 2
Geotechnical aspects of planning and design of MSW and Hazardous waste Landfills
Unit 3
Geotechnical aspects of planning and design of slurry ponds - ash ponds and tailing ponds.
Unit 4
Geotechnical aspects of detection & monitoring of subsurface contamination and control & remediation of contaminated sites.
Unit 5
Rehabilitation of waste dumps and geotechnical re-use of waste.

References:

1. Rowe R.K.,"Geotechnical and Geoenvironmental Engineering Handbook" Kluwer Academic Publications, London, 2000.

2. Reddi L.N. and Inyang, H. I.,"Geoenvironmental Engineering,Principles and Applications" Marcel Dekker Inc. New York, 2000.

3. Yong, R. N.,"Geoenvironmental Engineering, Contaminated Soils,Pollutant Fate, and Mitigation" CRC Press, New York, 2001.

4. Sharma H.D. and Reddy K.R.,"Geoenvironmental Engineering: Site Remediation, Waste Containment, and Emerging Waste Management Technologies" John Wiley & Sons, Inc., USA, 2004.

5. Fredlund D.G. and Rahardjo, H.,"Soil Mechanics for Unsaturated Soils" Wiley-Interscience, USA, 1993.

6. Mitchell, J.K.,"Fundamentals of Soil Behavior" Wiley, 2005.

7. Hillel D.,"Introduction to Environmental Soil Physics" Academic Press, New York, 2003.

Course outcomes (CO):

1. Students will be able to understand fundamentals of Geoenvironmental Engineering.
2. Students will have knowledge on planning and design of MSW and Hazardous waste Landfills.
3. Students will have adequate knowledge on planning and design of slurry ponds - ash ponds and tailing ponds.
4. Students will have adequate knowledge on subsurface contamination.
5. Students will have understanding on reuse of geotechnical waste.

Table 1: To establish the correlation between COs & POs

No. of Curse Outcome (CO)	Course Outcome
CO-1	Students will be able to understand fundamentals of Geoenvironmental Engineering.
CO-2	Students will have knowledge on planning and design of MSW and Hazardous waste Landfills.
CO-3	Students will have adequate knowledge on planning and design of slurry ponds - ash ponds and tailing ponds.
CO-4	Students will have adequate knowledge on subsurface contamination.
CO-5	Students will have understanding on reuse of geotechnical waste.

Table-2: Correlation between COs & POs Slight (LOW): 1 Moderate (MEDIUM): 2 Substantial (HIGH): 3 and for NO CORELATION: '-'

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO-1	3	2	1	2	3	3
CO-2	3	3	1	3	2	3
CO-3	3	3	3	3	3	2
CO-4	2	2	3	3	2	3
CO-5	3	3	3	2	2	2
Total	14	13	11	13	12	13
Average	2.80	2.60	2.20	2.60	2.40	2.60
Equivalent Avg. Attainment	**3**	**3**	**2**	**3**	**2**	**3**

Table 3: To establish the correlation between COs & PSOs

CO	PSO1	PSO2
CO-1	3	3
CO-2	3	3
CO-3	3	3
CO-4	3	3
CO-5	3	3
Total	15	15
Average	3	3
Equivalent Avg. Attainment	**3**	**3**

Syllabus for M.TECH (Environmental Engineering)
Third Semester

Sl. No.	Subject	Credit	Class Hours per Week	Marks
1	**PCE43P01:** Project and Thesis-I	**10**	**-----**	**100**

PROJECT AND THESIS-I
(PCE43P01)

Total Credit: 10
Contact Periods: (0L+0T+Full P)

The third semester is completely devoted to dissertation work. It is expected that the student will be carrying out substantial research work including exhaustive literature survey, formulation of the research problem, development/fabrication of experimental set-up (if any required) and testing, and analysis of initial results so obtained. The progress made during the semester may be evaluated through progress seminar(s). At the end of the semester, the students are required to submit written report followed by presentation and oral examination as per the Institute rules.

Syllabus for M.TECH (Environmental Engineering)
Fourth Semester

Sl. No.	Subject	Credit	Class Hours per Week	Marks
1	**PCE44P01:** Project and Thesis-II	**20**	**-----**	**300**

PROJECT AND THESIS-II
(PCE44P01)

Total Credit: 20
Contact Periods: (0L+0T+Full P)

The fourth semester is also completely devoted to dissertation work. It is expected that the student will be completing most of the experimental/computation works and analyzed the results so obtained as decided in the formulation part of the research problem. The progress made during the semester may be evaluated through progress seminar(s). The students will be required to submit the research work in the form of dissertation as per the Institute rule. The final examination (presentation as well as oral) will be conducted by a duly constituted examination panel as per the Institute rules.

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