MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY
(AUTONOMOUS)

DEPARTMENT OF CIVIL ENGINEERING

M.TECH
in
ENVIRONMENTAL SCIENCE AND ENGINEERING

CURRICULUM & SYLLABI

FOR

M. TECH DEGREE PROGRAMME

IN

ENVIRONMENTAL SCIENCE AND ENGINEERING

2026 SCHEME (AUTONOMOUS)

MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

(Approved by AICTE, Autonomous Institution Affiliated to APJ Abdul Kalam Technological University)

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MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

Vision and Mission of the Institution

Vision

To be an Institution moulding globally competent professionals as epitomes of Noble Values.

Mission

To transform the Youth as technically competent, ethically sound and socially committed professionals, by providing a vibrant learning ambience for the welfare of humanity.

DEPARTMENT OF CIVIL ENGINEERING

Vision and Mission of the Department

Vision

To be a Centre of Excellence in Civil Engineering education with a global perspective,creating ethically strong engineers for the service of society.

Mission

To provide Engineering Education which can create exemplary professional Civil Engineers of high ethics with strong conceptual foundation coupled with practical insight, to serve the industry and community.

PROGRAMME OUTCOMES

Program outcomes are the attributes that are expected to be demonstrated by a graduate after completing the course.

PO1: An ability to independently carry out research/ investigation and development work in engineering and allied streams.

PO2: An ability to communicate effectively, write and present technical reports on complex engineering activities by interacting with the engineering fraternity and with society at large.

PO3: An ability 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 apply stream knowledge to design or develop solutions for real world problems by following the standards.

PO5: An ability to identify, select and apply appropriate techniques, resources and state-of-the-art tool to model, analyze and solve practical engineering problems.

PO6: An ability to engage in life-long learning for the design and development related to the stream related problems taking into consideration sustainability, societal, ethical and environmental aspects.

PO7: An ability to develop cognitive load management skills related to project management and finance which focus on Entrepreneurship and Industry relevance.

PROGRAMME SPECIFIC OUTCOMES

PSO1: An ability to analyze complex environmental systems and design sustainable, technically sound and cost-effective engineering solutions for water, wastewater, solid waste, air quality and climate change–induced challenges using advanced engineering tools, modelling techniques and experimental methods.

PSO2: An ability to conduct independent research, evaluate emerging environmental technologies and policies and develop innovative and ethical solutions for complex environmental engineering problems.

CONTENTS

1. Semester-wise Distribution of the Courses

a) Semester I (M1)									
Slot	**Course Type**	**Course Code**	**Course Name**	**Marks**		**Hours**			**Credit**
				CIA	**ESE**	**L**	**T**	**P**	
A	PCC	26MA061C	Probability and Statistics	50	50	4	0	0	4
B	PCC	26CE361A	Environmental Chemistry and Microbiology	50	50	4	0	0	4
C	PCC	26CE361B	Physico-Chemical Processes for Water and Wastewater Treatment	50	50	4	0	0	4
D	PEC	26CE362X	Program Elective Course 1	50	50	3	0	0	3
E	PEC	26CE362X	Program Elective Course 2	50	50	3	0	0	3
S	AC	26AC061A	Research Methodology and IPR	50	50	2	0	0	0
T	LBC	26CE369A	Environmental Monitoring Laboratory I	100	-	0	0	3	2
Total				**400**	**300**	**20**	**0**	**3**	**20**

Teaching Assistance: upto 6 hours

Program Elective Courses in M1 and M2 must be chosen from a single basket of all PECs.

b) Semester II (M2)									
Slot	**Course Type**	**Course Code**	**Course Name**	**Marks**		**Hours**			**Credit**
				CIA	**ESE**	**L**	**T**	**P**	
A	PCC	26CE361C	Biological Wastewater Treatment	50	50	4	0	0	4
B	PEC	26CE362X	Program Elective Course 3	50	50	3	0	0	3
C	PEC	26CE362X	Program Elective Course 4	50	50	3	0	0	3
D	IEC/ SAEC*	26CE366X/ 26CE064X	Industry Elective/ Skill/Ability Enhancement Course	50	50	3	0	0	3
S	PR	26CE367A	Mini project	100	-	0	0	6	3
T	LBC	26CE369B	Environmental Monitoring Laboratory II	100	-	0	0	3	2
Total				**400**	**200**	**13**	**0**	**9**	**18**

Teaching Assistance: Upto 6 hours

***Marks / GPA earned in this SAEC will be used for awarding GPA for this course.

c) Semester III (M3)									
Slot	**Course Type**	**Course Code**	**Course Name**	**Marks**		**Hours**			**Credit**
				CIA	**ESE**	**L**	**T**	**P**	
A	SAEC**	26CE074X	Skill/Ability Enhancement Course	To be successfully completed		-	-	-	3
D	PR	26CE378A	Project (Phase I)/	100	-	0	0	24	16
			Project/	100	100	0	0	24	
			Internship	100	-	Industry norms			
Total				**100**	**-/ 100/ -**	**24/Industry norms**			**19**

Teaching Assistance for students doing Project (Phase I)/ Project in the college: 5 hours

**This SAEC can be carried out at any time from M1 to M3, and credited in M3.

d) Semester IV (M4)									
Slot	**Course Type**	**Course Code**	**Course Name**	**Marks**		**Hours**			**Credit**
				CIA	**ESE**	**L**	**T**	**P**	
D	PR	26CE378B	Project (Phase II)/	100	100	0	0	24	16
			Internship/	100	-	Industry norms			
			Project	100	100	0	0	24	
Total				**100**	**100/ - /100**	**24/Industry norms**			**16**

Teaching Assistance for students doing Project (Phase II)/ Project in the college: 5 hours

LIST OF PROGRAM ELECTIVE COURSES

Category Code	Course Number	Course Name	L	T	P	Credit
PEC	26CE362A	Environmental Impact Assessment and Management	3	0	0	3
	26CE362B	GIS and Remote Sensing for Environmental Applications	3	0	0	3
	26CE362C	Instrumental and Analytical Techniques in Environmental Engineering	3	0	0	3
	26CE362D	Geo-Environmental Engineering and Technology	3	0	0	3
	26CE362E	Environmental Health, Hygiene and Safety	3	0	0	3
	26CE362F	Mitigation and Adaptation Strategies in Climate Change	3	0	0	3
	26CE362G	Environmental System Modelling	3	0	0	3
	26CE362H	Ecological Engineering for Environmental Systems	3	0	0	3
	26CE362I	Air Pollution and Control Technologies	3	0	0	3
	26CE362J	Advanced Wastewater Treatment Technologies	3	0	0	3
	26CE362K	Environmental Biotechnology and Bioremediation	3	0	0	3
	26CE362L	Environmental Hydrology	3	0	0	3
	26CE362M	Contaminant Transportation and Remediation	3	0	0	3
	26CE362N	Environmental Toxicology	3	0	0	3
	26CE362O	Solid and Hazardous Waste Management	3	0	0	3
	26CE362P	Computational Methods in Environmental Engineering	3	0	0	3
	26CE062A	Data Science and ML in Civil Engineering	3	0	0	3

LIST OF INDUSTRY-BASED ELECTIVE COURSES

Slot	Category Code	Course Number	Course Name	L	T	P	Credit
E	IEC	26CE366A	Industrial Effluent Management	3	0	0	3
		26CE366B	Circular Economy for Sustainable Resource Management	3	0	0	3
		26CE366C	Environmental Nanotechnology	3	0	0	3

2. SYLLABI FOR VARIOUS COURSES

a) SEMESTER I (M1)

PROGRAMME CORE COURSE (PCC)

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
26MA061C	Probability and Statistics	PCC	4	0	0	4	2026

i) COURSE OBJECTIVES

The objective of this course is to expose the students to the fundamental concepts of probability and statistics. The course aims to equip the students to find solutions for many real-world Environmental Engineering problems and to understand basic data analysis tools by applying the principles of Statistics.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Apply the concepts of statistics and probability distributions to environmental data.	Apply
CO2	Formulate and test hypotheses, including confidence intervals and significance tests.	Apply
CO3	Apply statistical tools such as ANOVA, regression models, and experimental designs.	Apply
CO4	Identify principal components and apply data techniques to multivariate and time-series data.	Apply
CO5	Develop forecasting and predictive models for environmental and data-driven applications.	Apply

iii) SYLLABUS

Probability Distributions: Discrete and Continuous Standard distributions: Binomial, Poisson, Normal and Exponential distributions Fitting of distributions Statistical Inference: Sampling distributions- Interval estimation-Testing of hypotheses. Analysis of variance: Completely randomized designs and randomized block designs. Latin square designs –Factorial experiments. Correlation and Regression models: Linear and multiple correlation and regression Principal component analysis. Time Series Models: Components of time series-Identifying linear trend- Smoothing, Forecasting

iv) REFERENCES

1) Johnson R. A. , Miller I., Freund J. Miller and Freund's ,*Probability and Statistics for Engineers,* Pearson, 10th edition, 2020

2) Benjamin Jack R. and Cornell Allin C., *Probability, Statistics and Decision for Civil Engineers*, Dover Publications, 2014

3) Gupta. S. C. and Kapoor. V. K, *Fundamentals of Mathematical Statistics*, Sultan Chand and Sons, 2020

4) Raymond H. Myers, Douglas C. Montgomery, Christine M. Anderson-Cook, *Response Surface Methodology: Process and Product Optimization Using Designed*

Experiments, 4th edition, ISBN: 978-1-118-91601-8, 2016

5) Douglas C. Montgomery, Cheryl L. Jennings, Murat Kulahci , *Introduction to Time Series Analysis and Forecasting*, John Wiley & Sons, 2nd Edition, 2015

6) Papoulis A, Pillai S.U., *Probability, Random Variables and Stochastic Processes*, McGraw Hill, 2022

7) Schiller J., Srinivasan R.A., Spiegal M., *Schaum's Outline of Probability and Statistics*, McGraw Hill, 2017

8) Ross S., *Introduction to Probability and Statistics for Engineers and Scientists*, Elsevier, 6th edition, 2021

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Probability Distributions:** Discrete and continuous random variables. PMF, PDF and CDF expectation, mean and variance. Binomial, Poisson, Exponential and Normal distributions. Probability computation and fitting of Binomial and Poisson distributions.	**14**
II	**Statistical Inference:** Populations and samples. Sampling distributions of mean and variance. Confidence intervals for mean and variance. Hypothesis testing, including tests for means, proportions, variances, paired samples and Chi-square test for goodness of fit and independence.	**13**
III	**Analysis of variance:** Analysis of variance. Completely randomized designs and randomized block designs. Latin square designs. Factorial experiments - Two-factor experiments (overview only)	**10**
IV	**Correlation and Regression models:** Linear regression and correlation, method of least squares, normal regression analysis, normal correlation analysis, correlation coefficient. Multiple linear regression, normal equations Principal components (brief overview only)	**13**
V	**Time Series Models:** Components of time series. Identifying linear trend- semi averages method and least squares method. Smoothing- moving averages, weighted moving averages, exponential smoothing using one smoothing coefficient. Forecasting, measuring forecasting accuracy	**10**
	Total Hours	**60**

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
26CE361A	Environmental Chemistry and Microbiology	PCC	4	0	0	4	2026

i) COURSE OBJECTIVES

Environmental chemistry is considered important at the societal level as it is associated with pollutants, environmental impact, environmental management and contamination reduction. It covers the basic concepts and parameters related with Environmental Engineering and related issues. Environmental Microbiology helps to define the concepts in Microbiology in relation to the environment. It helps the students to understand the basic microbiological practices to be adopted for monitoring the quality of air, water and soil.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Apply the concepts of Physical Chemistry involved in environmental processes for contaminant remediation	Apply
CO2	Identify analytical methods for the qualitative and quantitative determination of various environmental parameters	Apply
CO3	Identify the environmental impacts of biomolecules, surfactants, dyes, radioactive pollutants and emerging contaminants	Apply
CO4	Identify and characterize microorganisms found in various environmental settings using microbial techniques	Apply
CO5	Analyse the interactions between microorganisms and pollutants and the role of microbes in biogeochemical cycling and contaminant remediation	Analyse

iii) SYLLABUS

Fundamentals of Physical Chemistry: Solutions, Kinetics and order of reactions, types of reactions, solvent extraction, ionization, surface and colloidal chemistry

Analytical methods in Environmental Chemistry: Spectrophotometry, Chromatography, Nephelometry, Potentiometric titration, Conductometric titration

Biomolecules and Environmental Pollutants: Biomolecules, surfactants, dyes, and radioactive pollutants, environmental effects- Eutrophication and Degradation, Emerging Contaminants

Fundamentals of Microbiology: Staining methods, Microscopy, Growth curve of microbes, Microbial metabolism, Physical and chemical control of microorganisms, Antibiotics, Food spoilage and food preservation

Environmental Microbiology: Aeromicrobiology, Air borne diseases and control, MPN and membrane filter techniques, Water borne diseases and control, Biogeochemical cycling,

Microbial Leaching, Biopesticides, Biofertilisers

iv) REFERENCES

1) Clair N. Sawyer, Peryl Mc Carty, *Chemistry for Environmental Engineering*, Mc Graw Hill Education, 5th edition, ISBN: 978-0070532441, 2017
2) B. K. Sharma*, Instrumental Methods of Chemical Analysis*, Krishna Prakasan Media (P) Ltd., ISBN: 978-8182836730, 2014
3) B.R. Puri, L.R. Sharma, M.S. Pathania, *Principles of Physical chemistry*, Vishal Publishing, 47th edition, ISBN: 978-9382956013, 2020
4) Donald V. and Judith G.V., *Biochemistry*, Wiley & Sons Asia Pvt. Ltd., New Jersey, 4th edition, ISBN: 978-0470570951, 2011
5) Berg, J.M., Tymoczko, J.L. and Stryer L., *Biochemistry*, Freeman and Company, New York, 7th edition, 2012
6) Peter Atkins, Julio de Paula, James Keeler, *Physical Chemistry*, Oxford HED, 4thedition, 2018
7) A. Skoog and Donald M. West, *Fundamentals of Analytical Chemistry*, Cengage Learning, 9th edition, 2013
8) Raina. M. Maier, Ian L. Pepper and Charles P. Gerba, *Environmental Microbiology*, Elsevier India Pvt ltd, New Delhi, 2nd edition, 2008
9) Ian L.Pepper, Charles P. Gerba and Terry J. Gentry, *Environmental Microbiology*, Elsevier, 3rd edition, 2015
10) Michael. J. Pelczar, *Microbiology*, Tata McGraw Hill company Ltd, New Delhi, 5thedition, ISBN: 978-0074623206, 2001
11) Anathanarayanan and Panikers, *Text book of Microbiology*, Orient Longman Pvt Ltd., 7th edition, 2007
12) P.D.Sharma, *Microbiology*, Rastogi publications, Meerut, 4th edition, 2019

v) COURSE PLAN

Module	Contents	Hours
I	**Fundamentals of Physical Chemistry:** Introduction-solutions-normal, molar and molal solutions- vapour pressure, Henry's law, Graham's law, Raoult's law- Law of mass action - chemical equilibrium, Le Chatelier's principle Fundamentals of chemical kinetics, Types of reactions, Rate and order of reactions- Zero order, First order, Second order Reactions- Derivation of first order kinetic equation – Distribution coefficient-Principle of solvent extraction Theory of ionization, pH and buffers -Henderson Hasselbalch's equation -Basic concepts from surface and colloidal chemistry – preparation, classification, Properties and their stability - Zeta potential and its determination	**12**

II	**Analytical methods in Environmental Chemistry:** Beer-Lambert law, Principle, instrumentation and applications of spectrophotometry -UV-visible spectroscopy, IR spectroscopy, Atomic Absorption Spectroscopy (AAS), Nephelometry and Turbidimetry Principles of Chromatography – thin layer and paper – adsorption – partition – ion exchange- HPLC, GC-size exclusion – electro chromatography Potentiometric titration of Iron, Acid-base conductometric titrations	**12**
III	**Biomolecules, Environmental Pollutants** Biomolecules - proteins, carbohydrates, lipids, enzymes, nucleic acids, vitamins Surfactants- cationic, anionic and non-ionic detergents, Environmental effects- Eutrophication and Degradation. Dyes- chemical classification (azo, anthraquinone, Phthalocyanines), Environmental impacts of Dyes Radioactive pollution-sources, methods of monitoring and control Emerging contaminants- Microplastics, PFAS, Pharmaceutical and Personal Care Products	**12**
IV	**Fundamentals of Microbiology:** General properties of microorganisms- General properties of bacteria, fungi, algae, protozoa, rickettsia and chlamydia. Characterization & classification of microorganisms Morphology and structure of bacteria. Staining methods. Microscopy- Light and Electron Microscopy Culture media and growth factors for microbes. Enumeration techniques for bacteria .Growth curve of microbes Microbial metabolism- Aerobic and anaerobic growth. Physical and chemical control of microorganisms-sterilization principles and techniques. Antibiotics-mechanism of action. Microbes associated with food spoilage, food preservation methods	**13**
V	**Environmental Microbiology**: Aeromicrobiology, outdoor and indoor, bioaerosol sampling. Air borne diseases and control Concept of indicator organisms. - Total coliforms, MPN and membrane filter techniques. Water borne diseases and control. Role of microorganisms in biogeochemical cycling. Microbial leaching. Biopesticides and biofertlizers	**11**
	Total hours	**60**

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
26CE361B	Physico-Chemical Processes for Water and Wastewater Treatment	PCC	4	0	0	4	2026

i) COURSE OBJECTIVES

This course provides an in-depth understanding of physico-chemical principles and processes used in water and wastewater treatment. Emphasis is placed on fundamental mechanisms, process design, kinetics, reactor configurations and emerging technologies for the removal of particles, dissolved contaminants and transformation of chemical species.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Identify the appropriate physico-chemical treatment options for water and wastewater.	Apply
CO2	Discuss the mechanisms behind the physical and chemical treatment processes and their advantages and limitations.	Apply
CO3	Analyse water and wastewater quality parameters and select suitable physico-chemical processes for the removal of various contaminants.	Analyse
CO4	Design physico-chemical treatment units for water and wastewater using standard guidelines and design criteria.	Apply
CO5	Suggest appropriate methods for the treatment of various types of wastewater.	Apply

iii) SYLLABUS

Physical and chemical characteristics of water and wastewater, Water quality standards
Classification of contaminants- particles, solutes, chemical species
Fundamentals of Mass transfer and reactor concepts
Particle separation processes- Screening, Sedimentation, Floatation, Coagulation, Flocculation, Filtration
Solute separation processes- Gas transfer, Aeration, Adsorption, Ion exchange, Chemical precipitation
Species transformation processes- Chemical oxidation/reduction processes, Advanced oxidation processes, Disinfection, Electrochemical and Photochemical transformation
Membrane processes, Case studies on wastewater treatment in chemical and allied industries, emerging contaminants

iv) REFERENCES

1) Metcalf & Eddy, Inc., George Tchobanoglous, Franklin Burton and H. David Stensel, *Wastewater Engineering; Treatment and Reuse*, McGraw Hill Education, 4th edition, ISBN: 978-0070495395, 2017
2) Metcalf & Eddy, Inc., George Tchobanoglous, H. David Stensel, Ryujiro Tsuchihashi, Franklin Burton, *Wastewater Engineering: Treatment and Resource Recovery*, McGraw Hill, 5th edition, ISBN: 978-0073401188, 2013
3) Ronald L. Droste, *Theory and practice of water and wastewater treatment*, John Willy and sons (ASIA) Pvt. Ltd., 2nd edition, ISBN: 978-1-119-31236-9, 2018
4) Mark J. Hammer, Mark J. Hammer Jr., *Water and wastewater technology*, Prentice Hall of India Pvt Ltd, 7th edition, ISBN: 978-0135114049, 2011
5) Howard S. Peavy, Donald R. Rowe and George Tchobanoglous, *Environmental Engineering*, McGraw Hill Education, ISBN: 978-9351340263, 2017
6) Arcadio P. Sincero and Gregoria A. Sincero, *Environmental Engineering: A Design Approach*, Pearson Education Services Pvt. Ltd., 2nd edition, 2016
7) Mackenzie L. Davis, *Water and Wastewater Engineering: Design Principles and Practice*, McGraw Hill, 2010
8) John C. Crittenden, R. Rhodes Trussell, David W. Hand, Kerry J. Howe, George Tchobanoglous, *MWH's Water Treatment: Principles and Design*, 3rd Edition, 2012
9) AWWA, *Water Quality and Treatment: A handbook on drinking water,* 6th edition, 2011
10) *Standard Methods for the Examination of Water and Wastewater*, American Public Health Association, American Water Works Association, Water Environment Federation, 23rd edition, 2017
11) IS: 10500:2012 Drinking Water- Specification, Second revision, Bureau of Indian Standards, 2012
12) *Manual on Water Supply and Treatment Systems*, *Part A: Engineering-Planning, Design and Implementation*, Central Public Health and Environmental Engineering Organisation, Ministry of Housing and Urban Affairs, Govt. of India, 4th edition, 2024
13) *Manual on Sewerage and Sewage Treatment Systems, Part A: Engineering,* Central Public Health and Environmental Engineering Organisation, Ministry of Urban Development, Govt. of India, 3rd edition, 2013

v) COURSE PLAN

Module	Contents	Hours
I	**Fundamentals of Physico-Chemical Treatment:** Water and wastewater quality- physical and chemical characteristics, Water quality standards and regulatory requirements, Classification of contaminants- particles, solutes, chemical species Mass transfer principles in water and wastewater treatment, Reactor concepts- Ideal reactors, non-idealities, mass balance in various reactor configurations.	**10**
II	**Particle separation processes:** Screening-types, design of bar screen, Sedimentation-theory, types of settling, design of sedimentation tanks Floatation processes- dissolved air floatation, induced air floatation. Coagulation and flocculation –mechanisms, coagulants, particle surface charge, surface potential and stability of colloidal dispersions Filtration- mechanisms and types, theory and design of Rapid sand filters, Multimedia filters	**13**
III	**Solute separation processes:** Gas transfer processes, Diffused and surface Aeration , Air stripping of volatile contaminants in packed tower, Adsorption and ion exchange processes- principles, sorption isotherm models and rates considerations- Sorption in completely mixed and packed bed reactors, Chemical Precipitation processes	**13**
IV	**Species transformation processes:** Chemical oxidation and reduction processes Disinfection processes- using chlorine, UV and Ozone Advanced oxidation processes (AOP)- theory, applications of AOPs, Electrochemical and photochemical transformation processes	**12**
V	**Membrane processes and Case Studies:** Membrane processes for removal of micro pollutants, Ultrafiltration, Microfiltration, Nanofiltration, Membrane fouling-mechanisms and control strategies Desalination processes- Reverse osmosis, Electrodialysis Hybrid physico-chemical systems, Case studies on physico-chemical treatment of wastewater from chemical and allied industries, treatment of emerging contaminants	**12**
	Total hours	**60**

PROGRAM ELECTIVE COURSES (PEC)

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
26CE362A	Environmental Impact Assessment and Management	PEC	3	0	0	3	2026

i) COURSE OBJECTIVES

The goal of this course is to expose the students to the fundamental concepts and purpose of Environmental Impact Assessment and the need for Environmental Management. After this course, students will be able to assess the impact of a particular developmental project and be able to prepare an EIA report.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO 1	Explain the principles, processes and legal frameworks governing Environmental Impact Assessment and management.	Understand
CO 2	Apply EIA methodologies and tools for conducting various impact analysis studies.	Apply
CO 3	Design comprehensive Environmental Management Plan that include environmental monitoring, auditing and environmental management systems.	Apply
CO 4	Analyse the impacts of different types of development projects and assess the effectiveness of mitigation strategies.	Analyse

iii) SYLLABUS

Introduction to EIA: EIA Guidelines and notification of Govt. of India- Procedure for reviewing Environmental Impact Analysis and statement- Types of EIA, Types of Impact, Process and Methods of EIA

Various Impact Analysis: Air quality impact analysis - Water quality impact analysis- Vegetation and wildlife impact analysis – Energy impact analysis- Socio economic impact analysis

Environment Management Plan: Objectives & Components of EMP- Environmental Monitoring-Environmental Auditing- Environmental Management Systems (EMS)

EIA Case Studies: Nuclear Power plants-Hydroelectric Projects- Thermal Power Plants-Mining projects-Transportation projects- industries-development projects

iv) REFERENCES

1) Larry W. Canter, *Environmental Impact Assessment*, McGraw Hill , New York, 2nd edition, 1996

2) John Glasson, Riki Therivel and Andrew Chadwick, *Introduction to Environmental Impact Assessment*, Routledge, 4th edition, 2013

3) Peter Morris and Riki Therivel, *Environment Impact Assessment: Theory and Practice*,

Routledge, 3rd edition, 2009

4) Riki Therivel and Graham Wood, *Methods of Environmental and Social Impact Assessment,* Routledge, 3rd edition, 2017
5) Agarwal S. K., *Environmental Management*, A P H Publishing Company , New Delhi, 2005
6) Bhatia A. L., *Sustainable Environment Impact Assessment*, Avishkar Publishers, Jaipur, 2007
7) Shrivastava A. K., *Environment Impact Assessment*, A P H Publishing Company, New Delhi, 2003
8) Trivedi P. R., *Environment Impact Assessment*, A P H Publishing Company , New Delhi, 2012
9) Barthwal, R. R., *Environmental Impact Assessment*, New Age International Publishers, 2012
10) N.S. Raman, A.R. Gajbhiye, S.R. Khandeshwar, *Environment Impact Assessment*, IK International Publishing House, Pvt. Ltd. New Delhi, 2014
11) Ministry of Environment, Forests and Climate Change, EIA Notification 2006
12) World Bank, *Environmental Assessment Source Book*, Environment Dept., Washington D.C., 1996

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to EIA**: Concept and purpose of EIA, Evolution of EIA, EIA Guidelines and notification of Govt. of India-Procedure for EIA – Components, Stakeholders of EIA, Online EIA clearance in PARIVESH Portal, Public participation in decision making, Projects requiring environmental clearance, Framework of SEIAA and SEAC, Overview of Draft EIA 2020 Notification Types of EIA- Rapid EIA, Comprehensive EIA, Strategic Environment Assessment (SEA) Types of Impact-Primary & Secondary, Short Term & long term, Reversible and Non-Reversible, Positive and Negative impacts	9
II	**Process and Methods of EIA:** Screening, Scoping, Environmental Baseline data collection, Identification of Impacts- Prediction of Impacts, Consideration of alternatives Evaluation and assessment of impact- Assessment of effects on human beings, flora, fauna and geology Mitigation Measures, Environment Impact Statement Preparation Methods of EIA – (Leopold Matrix),Networks Method, Overlays Method, Index Method, Simulation Mode, Cost Benefit Analysis Role of GIS in EIA	9

III	**Impact Analysis:** Air quality impact analysis - air pollutants, sources, atmospheric interaction- environmental impact assessment methodology Water quality impact analysis – water quality criteria and standards, water quality impacts by development projects Vegetation and wildlife impact analysis – assessment methodologies Energy impact analysis- Energy impact considerations, organization and methodology Socio economic impact analysis- Types of socioeconomic impacts, basic steps in performing a socioeconomic impact assessment	**9**
IV	**Environmental Management Plan (EMP):** Objectives of EMP, Components of EMP Post project monitoring- principles & types of monitoring, Environmental Auditing- Guidelines for Auditing, Objectives and benefit of Auditing, Steps in Auditing , Types of Auditing Environmental Management Systems (EMS)- Benefits of EMS, International Standard Organization and ISO 14001 Environmental, Social and Governance (ESG) Reporting	**9**
V	**EIA Case Studies:** Preparation of EIA for developmental projects - Factors to be considered in making assessment decisions, Water Resources Project, Pharmaceutical industry, Thermal plant, Mining, Nuclear fuel complex, Highway project, Sewage treatment plant, CETP, Treatment Storage Disposal Facility, Municipal Solid waste processing plant, Tannery industry. Software for rapid EIA.	**9**
	Total hours	**45**

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
26CE362B	GIS and Remote Sensing for Environmental Applications	PEC	3	0	0	3	2026

i) COURSE OBJECTIVES:

Goal of this course is to expose the students to the fundamental concepts of satellite remote sensing and various applications of GIS in environmental engineering. After this course, students will be able to process satellite information and perform data interpretation using GIS to solve various environmental problems.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO 1	Discuss the concepts, physics and characteristics of remote sensing and the capabilities of various satellite sensors.	Understand
CO 2	Make use of remote sensing datasets for digital image processing.	Apply
CO 3	Apply the principles of remote sensing in solving environmental engineering problems.	Apply
CO 4	Make use of the principles of GIS in various environmental applications.	Apply

iii) SYLLABUS

Introduction to Remote Sensing – Physics of remote sensing, Types, Elements of digital image interpretation, image correction techniques

Application of Remote sensing- Analysis of land surface biophysical properties, Development of terrain models, soil type and soil moisture monitoring, vegetation indices, Remote sensing of environment

Introduction to GIS, Data Analysis in GIS

Application of GIS in environmental problems

iv) REFERENCES

1) Lillesand T.M. and Kiefer R.W., *Remote sensing and Image Interpretation*, 7th edition,John Wiley and Sons, 7th edition, 2015
2) AnjiReddy M., *Remote Sensing and Geographical Information System*, BSP Publications., 4th edition, 2001
3) Chang K. , *Introduction to Geographic Information Systems*, Tata McGraw Hills, New Delhi, 4th edition, 2005
4) *Manual of Remote Sensing*, American Society of Photogrammetry and Remote

Sensing, 1993

5) Sabins F.F. Jr., *Remote Sensing Principles and Interpretation*, W.II. Freeman and Company, 3rd edition,1996

6) Clarke, K.C. Parks B.O., and Crane M.P., *Geographic Information Systems and Environmental Modelling*, PHI of India , New Delhi, 2006

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Remote sensing**: Physics of remote sensing, interaction of earth surface features with electromagnetic radiations, atmospheric windows, effects of atmosphere, spectral signatures Types of remote sensing, active and passive measurements, platform characteristics, satellite orbits, Sensor characteristics-spatial, temporal, spectral, radiometric resolutions, principles of image processing, methods of encoding image data-BIL, BIP, BSQ, False Color Composite (FCC) Elements of digital image interpretation, image correction techniques atmospheric, geometric and radiometric, principles of photogrammetry, algorithms and data products.	9
II	**Application of Remote sensing:** Analysis of land surface biophysical properties, land surface temperature, classification of land use and land cover-supervised and unsupervised techniques Use of satellite data for monitoring urban heat islands, illegal dumping or deforestation trends Development of terrain models- DEM & DTM, soil type and soil moisture monitoring, vegetation indices Remote sensing of environment- aerosol optical depth, air quality monitoring using satellite data, Remote sensing of water quality, flood mapping, ocean remote sensing for oil spill detection	9
III	**Introduction to GIS:** Introduction to GIS, History and development of GIS, components of GIS, Coordinate reference systems, datum and projections, map scales Georeferencing, Spatial data concepts, data sources in GIS, data input methods, file formats for GIS standard GIS packages Type of data, Spatial and attribute data, Data models- vector and raster, Spatial data structure- Vector data structure and raster data structure, Database management systems (DBMS), Relational	9

	database management systems (RDBMS)	
IV	**Data Analysis in GIS:** Spatial data analysis, single layer operations- spatial and attribute query, buffer analysis, point pattern analysis, network analysis, surface analysis, Interpolation Multi-layer operations-topological overlays, point in polygon, line in polygon, polygon in polygon, logical operators-AND, OR, NOT, XOR, vector overlay operations-Clip, erase, split, union, identity and intersect; raster calculators Global navigation satellite systems- types, Global positioning system components and principle, satellite ranging- calculating position, GPS errors and biases, Differential GPS (DGPS)	**9**
V	**Application of GIS in environmental problems:** Familiarizing a GIS tool, Application of GIS in Urban planning, agriculture, land use/land cover changes Application of GIS in disaster management, natural resources management, Irrigation water management Application of GIS in mapping and navigation, site suitability analysis for infra projects, environmental science, network analysis	**9**
	Total hours	**45**

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
26CE362C	Instrumental and Analytical Techniques in Environmental Engineering	PEC	3	0	0	3	2026

i) COURSE OBJECTIVES

Instrumental and analytical techniques in Environmental Engineering include studies and methods to separate, identify, and quantify parameters related with Environmental Engineering. This helps the students to create a thorough knowledge about research related activities in Environmental Engineering. This paper also covers the concepts of Chemistry related issues of Environmental Engineering. Hence this paper is very essential for Environmental Engineers and researchers.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Discuss the biochemical techniques for the characterization of various environmental parameters.	Apply
CO2	Formulate the procedures adopted for analysis of various test samples.	Apply
CO3	Analyse various biochemical parameters related with soil, water and air.	Analyse
CO4	Identify the various nanotechnology techniques for Environmental analysis.	Apply
CO5	Discuss suitable novel methods for Environmental research applications.	Apply

iii) SYLLABUS

Introduction to Environmental Chemical analysis

Principles and applications of Analytical Techniques

Spectrophotometry and X-ray Techniques

Advanced separation techniques

Nanotechnology techniques used in Environmental Engineering

iv) REFERENCES

1) Francis Rouessac and Annick Rouessac, *Chemical Analysis: Modern Instrumentation Methods and Techniques*, Wiley, 3rd edition, 2022

2) Chatwal and Anand , *Instrumental methods of analysis*, Dhanpat Rai, 2001

3) Clair N. Sawyer, PeryL. Mc Carty, *Chemistry for Environmental Engineering*, McGraw Hill, 4th edition, 2002

4) Maheshwar Sharon, Madhuri Sharon, *Bionanotechnology,* CRC Press INC, 1st edition, 2012

5) Holtzhauer, M., *Basic Methods for the Biochemical Lab*, 1st English edition, Springer, 2006

6) Popek, E., *Sampling and Analysis of Environmental Chemical Pollutants, A Complete Guide*, 2nd Edition,Elsevier, 2017

7) Andrew, D. E., Lenore, S. G., Eugene, W. R., Arnold, E. G., *Standards Methods for the Examination of Water and Wastewater Analysis*, 21st Edition, APHA, Washington DC, 2005

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Environmental Chemical Analysis:** Soils: Sampling and storage, Pre-treatment, Extraction of organic contaminants, extraction of available ions-Dissolution technique for the determination of total metal concentration in soil- Determination of pH, Cation Exchange Capacity (CEC), total and available metal ions Air: Air sampling techniques and analytical methods for monitoring SO_2, NO_2, CO, H_2S and Suspended Particulate Matter (SPM) Water and Wastewater: Sampling - grab and composite sampling, preservation, storage, pre-treatment	9
II	**Principles and applications of Analytical Techniques:** Principles and applications (any three for each) of selected analytical methods used in environmental chemical analysis: Titrimetry, Gravimetry, Colorimetry Principle, instrumentation and applications of Amperometric titrations (sulphate, Magnesium, lead) Conductometry- Measurement of conductance, TDS, conductometric titration-acid-base, precipitation (chloride estimation). Principle and applications of Nephelometry and Turbidimetry, Turbidimetric titration (Ba^{2+} Vs Sulphate) Potentiometry – acid base titrations	9
III	**Spectrophotometry and X-ray Techniques:** Principle, Instrumentation and applications of UV Visible spectrophotometry, IR Spectrophotometry Principle, instrumentation and applications of Atomic Absorption Spectroscopy (AAS), Atomic Emission Spectrophotometry-Flame photometry, Inductively Coupled Plasma Mass Spectrometry (ICP-MS) Basic principles and applications of X-Ray Fluorescence spectroscopy (XRF), X-Ray Diffraction studies and X-Ray Photoelectron spectroscopy (XPS)	9

IV	**Advanced separation techniques:** General principle of chromatography, Definitions-Elution, Retention time, Retention volume, Normal and Reverse phase chromatography, Retention factor. Theory, instrumentation and applications Gas Chromatography, High-Pressure Liquid Chromatography (HPLC), Gel permeation Chromatography (GPC), and Ion-exchange chromatography Electrophoresis and its applications, capillary electrophoresis. Gel electrophoresis: SDS- PAGE Isoelectric focusing, 2-D gel electrophoresis and their applications in Environmental Engineering	**9**
V	**Nanotechnology techniques used in Environmental Engineering:** Nanometerials- Definition, classification, characteristics. Nanocomposites Air purification using nanomaterials. Wastewater purification with nanobubbles, nanosorbents, nano filtration systems for heavy metals. Nano biosensors -glucose biosensors, alcohol biosensors. Nano particles for degradation of organic pollutants. Metal/Metal oxide nanoparticles for water treatment, Anti-microbial activity of silver nanoparticles-mechanism, Zerovalent Iron nanoparticles-synthesis, heavy metal removal, Silica nanoparticles synthesis, functionalisation and applications, Carbon nano tubes, Dendrimers, Quantum dots and nano sponges- definition, synthesis and environmental applications.	**9**
	Total hours	**45**

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
26CE362D	Geo-Environmental Engineering and Technology	PEC	3	0	0	3	2026

i) COURSE OBJECTIVES

Geo-environmental Engineering and Technology is a multidisciplinary subject which deals with Geotechnical and Environmental Engineering aspects. The subject has gone far beyond the conventional problems and the environmental engineers should be well informed about the geotechnical aspects while dealing with contaminated land. To take up these challenges, knowledge of soil behaviour, soil properties, soil chemistry etc related to soil mechanics is needed. The subject also offers an understanding of the microbial processes in the environment, microbial communities and microbial interactions.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Identify the geotechnical applications in environmental engineering.	Apply
CO2	Apply the basic concepts of landfill to solve the issues related to landfilling.	Apply
CO3	Select landfill liners and cover systems based on the requirements.	Apply
CO4	Identify appropriate methods of remediation for contaminated soil.	Apply
CO5	Apply the principles of geo-environmental engineering for the remediation of contaminated land and geotechnical reuse of waste materials.	Apply

iii) SYLLABUS

Introduction to Geo-environmental Engineering: Sources and impact of contamination, biogeochemical cycle. Soil-water-waste interaction, fate of contaminants. Soil microbiology

Landfill: Landfill -Leachate - Landfill gas- Settlement of landfills -Closure rehabilitation and expansion of landfills

Liners and cover system: Liner systems -Landfill cover system - Containment system-stability of waste containment systems

Contaminated land: Characterization of contaminated sites, contaminant release mechanism. Slurry disposal on land and ponds, dry waste in mounds

Soil remediation: Remediation of contaminated soil- Geotechnical reuse of waste materials. Soil Improvement using solid wastes – case studies. Waste dump - impact and remediation

iv) REFERENCES

1) Reddi L.N. and Inyang H.I., *Geoenvironmental Engineering: Principles and Applications*, Marcel Dekker Inc. Publication, 1st edition, 2020
2) R. N. Yong, *Geoenvironmental Engineering: Contaminated Soils, Pollutant Fate*, *Mitigation,* Lewis Publication, 2001
3) Hari D.Sharma, Krishna R. Reddy, *Geoenvironmental Engineering: Site Remediation, Waste Containment, and Emerging Waste Management Technologies*, John Wiley & Sons Inc., 1st edition, 2004
4) Sarsby R., *Environmental Geotechnics*, Thomas Telford, 2000
5) Daniel, D.E., *Geotechnical Practice for Waste Disposal,* Chapman, and Hall, London, 2012
6) Koerner, R.M., *Designing with Geosynthetics*, Prentice Hall, New Jersey, 5th edition, 2005
7) G.V. Rao and R. S. Sasidhar, *Solid waste Management and Engineered Landfills*, Saimaster Geo-environmental Services Pvt. Ltd. Publication, 2009
8) Donald L. Wise, Debra J. Trantolo, Hilary I. Inyang, Edward J. Cichon, *Remediation Engineering of Contaminated Soils*, Publisher: Marcel Dekker Inc., 2001

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Geo-environmental Engineering**: Sources and impact of contamination, Factors governing soil pollution, Biogeochemical cycle Soil- water-waste interaction, fate of contaminants Soil formation, composition, structure and properties of soil Soil microbiology- importance of micro organisms	**9**
II	**Landfill:** Landfill – capacity, layout, construction, landfill sections, design of landfill Leachate – quantity and quality, generation and control, collection and removal system, management Landfill gas- generation and control, landfill gas monitoring Settlement of landfills –mechanisms-mechanical compression, raveling, physicochemical changes, biochemical decomposition, factors affecting settlement Closure rehabilitation and expansion of landfills	**9**

III	**Liners and cover system**: Liner systems – types, composite clay liner, geomembranes and composite liners, geosynthetic clay liners Landfill cover system -requirements, components, types Containment system- displacement barriers, trench barriers, covers and horizontal barriers Flow and transport through barriers, stability of waste containment systems	**9**
IV	**Contaminated land:** Contaminated land – site investigation, sampling techniques, assessment and treatment selection Characterization of contaminated sites, contaminant release mechanism- Vapourisation, dusting, leaching Slurry disposal on land and ponds, dry waste in mounds Slurry ponds - planning and design, environmental control	**9**
V	**Soil remediation**: Remediation of contaminated soil- Exsitu and in situ remediation, bioremediation, phytoremediation, thermal remediation, pump and treat method, electrokinesis Geotechnical reuse of waste materials Soil Improvement using solid wastes – case studies Waste dump -impact and remediation	**9**
	Total hours	**45**

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
26CE362E	Environmental Health, Hygiene and Safety	PEC	3	0	0	3	2026

i) COURSE OBJECTIVES

Environment Health and Safety, give practical suggestions for protecting the environment along with maintaining health and safety. The course highlights the need for sanitation and safety in public and private spaces and equips the students to practise general hygiene and adopt measures for the control of various communicable diseases.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO 1	Identify the mode of transmission and control measures of various communicable diseases.	Apply
CO 2	Identify occupational and emerging diseases.	Apply
CO 3	Formulate the procedures adopted for survey and sample collection.	Apply
CO 4	Identify the sanitation practices and disease control measures adopted in public places.	Apply
CO 5	Discuss occupational health and evaluation of risk assessment.	Apply

iii) SYLLABUS

Communicable disease- Mode of transmission, Control measures
Occupational illness and emerging diseases, Food borne and water borne diseases, Sanitation related diseases and control measures
Occupational health and risk assessment- Accident Prevention and Elimination Plans, Fire Protection Techniques, Safety equipments. Radiation health -Biological effects of radiation, Bioterrorism. Emerging contaminants, Elements of risk assessment

iv) REFERENCES

1) Raina.M.Maier, Ian L. Pepper& Charles P. Gebra, *Environmental Microbiology*, Elsevier India Pvt ltd, New Delhi, 2nd edition, 2008
2) P.D. Sharma, *Microbiology*, Rastogi publications, Meerut, 4th edition 2019
3) R.K.Jain and Sunil S.Rao , *Industrial Safety , Health and Environment Management Systems,* Khanna publishers , New Delhi ,2006
4) Joseph A. Salvato ,Nelson N. Nemero, Franklin .J Agardy, *Environmental Engineering*, Wiley Interscience Publication, 5th edition, 2003
5) Slote L., *Handbook of Occupational Safety and Health*, John Willey and Sons, NewYork, 2nd edition, 1999
6) Ernest Hodgson, *A Text book of Modern Toxicology* , John Willey and Sons, NewYork,

4th edition , 2010

v) COURSE PLAN

Module	Contents	No. of hours
I	**Communicable diseases:** Infection and disease- Normal flora, pathogenicity, types and mode of transmission of diseases Bacterial diseases: pathogenicity, mode of transmission and control - Diarrhea, Typhoid , Cholera, TB , Plague Viral diseases: pathogenicity, mode of transmission and control - Chicken pox, Measles, Mumps, Rabies, AIDS, polio, Dengue Protozoal diseases: pathogenicity, mode of transmission and control - Malaria, Kala Azar, Gambia fever	9
II	**Occupational illness & Emerging diseases:** Asbestos, Silica , Lead , Nickel, Arsenic and Mercury toxicity Pathogenicity, mode of transmission and control- COVID19, Ebola virus disease , Nipah viral diseases, Tick fever, Zika viral disease, Monkey pox, Antimicrobial resistance and risk factors	9
III	**Survey on food borne & water borne diseases:** Investigation of water and food borne diseases outbreaks-general, sanitary survey, medical survey, samples, epidemiologic reports Environmental sample collection and processing-processing of soil and water samples for bacterial, viral and protozoal analysis Risks from Pathogens in Biosolids, Water and Food borne illness-disease transmission and control Air borne pathogens and toxins , bioaerosol control	9
IV	**Sanitation:** Swimming Pool sanitation, Restaurant sanitation, Slaughter house sanitation, Milk plant sanitation and Sanitation of Hospitals. Sanitation Related Diseases and Control Measure Vector borne and zoonotic diseases-transmission and control	9
V	**Occupational health & Risk assessment:** Accident Prevention and Elimination Plans, Fire Protection Techniques, Safety equipments Radiation health -Biological effects of radiation , Bioterrorism , Emerging contaminants-pharmaceuticals and personal care products, antibiotics, chemical household products, microplastics Elements of risk assessment -hazard identification ,exposure assessment, dose response assessment, risk characterization, microbial risk assessment	9
	Total Hrs.	**45**

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
26CE362F	Mitigation and Adaptation Strategies in Climate Change	PEC	3	0	0	3	2026

i) COURSE OBJECTIVES

The course aims to educate students about the causes and impacts, adaptive measures, and mitigation strategies of climate change. The course also covers the global and regional level policies and sustainable practices to control the factors influencing climate change. Students will gain knowledge in diverse domains of climate change.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Identify the changes, drivers and mechanisms of climate change	Apply
CO2	Assess international and national climate governance frameworks and policy instruments	Evaluate
CO3	Analyse the impacts of climate change on various environmental components, locally and globally	Analyse
CO4	Identify climate change adaptation strategies for urban, coastal and ecosystem systems	Apply
CO5	Recommend mitigation strategies considering technical, economic, and sustainability criteria	Evaluate

iii) SYLLABUS

Introduction to climate change: Atmospheric structure and composition- components of terrestrial climate system and their interactions. Drivers of climate change- Solar radiation and global energy budget. International Initiatives

Impacts of climate change: Impact on oceans- coastal regions- Polar Regions, Impact on agriculture-livestock- biodiversity- human health

Climate change vulnerability assessment, Economics of climate change, Case studies on climate change impacts, Climate Change Adaptation Needs and Practices: seasonal forecasting and early warning systems-using AI/ML, Improving preparedness – Responding to uncertainties- Adapting cities for climate change, role of blue and green infrastructure, ecosystem-based adaptation.

Climate change Mitigation: Long term and short-term mitigation options. Energy Conservation and Fuel Efficiency, Renewable energy sources

Non-energy approaches to Climate Change Mitigation: Recovery – sequestration - disposal of greenhouse gases. Carbon Conversion Technologies

Mitigation of Flood related issues. Case studies on climate disasters and mitigation

iv) REFERENCES

1) Dessler A., *Introduction to Modern Climate Change*, Cambridge University Press, 2nd edition, ISBN: 978-1108425226, 2019
2) Chen, W.Y., Suzuki, T., Lackner, M. (Eds.), *Handbook of Climate Change Mitigation and Adaptation*, 4th edition (updated), Springer, 2025.
3) Mark Maslin, *Climate Change: A Very Short Introduction*, Oxford University Press, 3rd edition, 2014
4) David Archer, *The Climate Crisis - An Introductory Guide to Climate Change,* Cambridge University Press, 2014, ISBN: 978-1107605666
5) The Royal Society, National Academy of Sciences, *Climate Change Evidence and Causes*, National Academies Press, 2014
6) Steven Earle, *A Brief History of the Earth's Climate: Everyone's Guide to the Science of Climate Change*, New Society Publishers, 2021
7) Dash Sushil Kumar, *Climate Change – An Indian Perspective*, Cambridge University Press India Pvt. Ltd, 2015
8) Navroz K. Dubash, *Handbook of Climate Change and India*, *Development, Politics and Governance* , Oxford University Press, 2011
9) Burroughs W.J., *Climate Change: A multidisciplinary approach*, Cambridge University Press, 2nd Edition, 2007
10) Barry R.G. and Chorley R.J., *Atmosphere, weather and climate*, Routledge, New York, 8th Edition, 2010
11) Mitsutsune Yamaguchi , *Climate Change Mitigation Balanced Approach to Climate Change,* Springer London Heidelberg New York, 2012
12) Wei-Yin Chen, Toshio Suzuki, Maximilian Lackner , *Handbook of Climate Change Mitigation and Adaptation*, Springer , 2nd edition, 2017
13) MoEFCC, *India's long-term low-carbon development strategy*, Ministry of Environment, Forest and Climate Change, Government of India, 2022
14) Intergovernmental Panel on Climate Change (IPCC)**,** *Climate Change 2023: Synthesis Report of the IPCC Sixth Assessment Report (AR6)* — IPCC, Geneva, Switzerland, ISBN: 978-92-9169-164-7, 2023

v) COURSE PLAN

Module	Contents	No. of hours
I	**Climate system and drivers of climate change:** Atmospheric structure and composition, Components of terrestrial climate system and their interactions. Drivers and mechanisms of climate change- Greenhouse effect, Greenhouse gases and their mechanism, Global warming potential (GWP) Solar radiation and global energy budget, Climate forcing, Climate Feedback, Albedo effect. Keeling curve- Human Footprints on global warming.	**9**

	Emission pathways and scenarios (RCPs, SSPs) International Initiatives: Brief history of international climate change negotiations- UNFCCC, Kyoto Protocol, Paris Agreement, SDG, IPCC Assessment Report , National Action Plan on climate change, State Action Plan on Climate Change	
II	**Impacts of climate change :** Impact on oceans, coastal systems, sea water intrusion Impact on polar regions, melting of ice caps, sea level rise Impact on agriculture, livestock, biodiversity, human health Climate change vulnerability and risk assessment frameworks Economics of climate change Case studies on climate change impacts (Global and Indian context)	**9**
III	**Climate change adaptation strategies:** Concepts of adaptation, resilience, and adaptive capacity, Climate information systems, seasonal forecasting and early warning systems-using AI/ML Decision-making under uncertainty and risk management Climate-resilient cities: infrastructure planning, building codes, and standards Role of green and blue infrastructure Ecosystem-based adaptation and nature-based solutions Selected case studies with emphasis on coastal and urban systems Geo-informatics in Climate Change Studies	**9**
IV	**Climate change Mitigation:** Characteristics of mitigation at regional and national context, Long term and short-term mitigation pathways Energy Conservation and Fuel Efficiency, Renewable energy technologies: Solar, wave, wind ,hydro, Geothermal, bioenergy India's Long-Term Low Emission Development Strategy Factors and constraints for adaptation and mitigation responses – case studies	**9**
V	**Non-energy approaches to climate change mitigation:** Carbon sequestration: biological, geological, and engineered approaches Carbon capture, utilization, and storage (CCUS) Carbon conversion technologies and negative emission technologies Integrated mitigation–adaptation co-benefits and trade-offs Flood risk mitigation and climate disaster risk reduction Case studies on extreme events and climate-resilient interventions	**9**
	Total hours	**45**

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
26CE362G	Environmental System Modelling	PEC	3	0	0	3	2026

i) COURSE OBJECTIVES

This course aims to provide introduction to the fundamental modelling concepts and their applications in simulating the pollutant fate and transport in the natural environmental systems. The mathematics behind various environmental pollution models with their uncertainties will be discussed.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO 1	Explain the complex structure of environmental systems and the basic concepts and terminology in environmental modelling and development	Understand
CO 2	Mathematically formulate the fate and transport of pollutants for environmental systems	Apply
CO 3	Simulate the fate and transport of contaminants in water, air and noise environments	Apply
CO 4	Interpret the results obtained from simulation studies for decision support and management	Evaluate

iii) SYLLABUS

Introduction to Environmental System Modelling: Role of models in environmental pollution studies- Environmental management and Modelling

Air pollution Modelling: Transport and dispersion of air pollutants sources– dispersion modelling

Water quality modelling: Discharge of pollutants into rivers- Behaviour of conservative and non- conservative substances-transport-advection, diffusion and dispersion. Dissolved oxygen in rivers, modification to Streeter-Phelps Equation Modelling

Groundwater Modelling: use of ground water models- ground water flow modelling- Seawater intrusion- basic concepts and modelling.

Noise Modelling**:** Modelling inputs-sound propagation factors- Noise mapping methodology- Modelling traffic noise.

iv) REFERENCES

1) Mustafa Aral M., *Environmental modelling and health risk analysis (ACTS/RISK),* Springer Science & Business Media, 2010
2) R.W. Boubel, D.L. Fox, D.B. Turner & A.C. Stern, *Fundamentals of Air Pollution*, Academic Press, New York, 4th edition, 2008
3) Steven C. Chapra, *Surface Water Quality Modelling*, Waveland Press, 2008
4) Todd David Keith, *Ground water Hydrology*, John Wiley and Sons, New York, 4th edition, 2004.

5) Murphy Enda, and Eoin A. King, *Environmental noise pollution: Noise mapping, public health, and policy*, Elsevier, 2nd edition, 2022
6) Nirmalkhandan N. , *Modelling Tools for Environmental Engineers and Scientists*, CRC Press, Boca Raton, Florida, 1st edition, 2001
7) Schnelle K.B. and Dey P.R., *Atmospheric Dispersion Modelling Compliance Guide*, McGraw-Hill, 1999
8) Randall J. Charbeneau, *Ground water Hydraulics and Pollutant transport*, Waveland Pr Inc., 1st edition, 2006.
9) Canter L.W, *Environmental impact assessment*, Mc- Grawhill Higher Education, 2nd edition, 1996

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Environmental System Modelling:** Role of models in environmental pollution studies- Environmental management and modelling -modelling principles Types of models-classification of mathematical models- deterministic, stochastic, continuous, discreet, static, dynamic, linear and non-linear Model building framework-model calibration, validation, verification and sensitivity analysis-model scales, error and uncertainty	8
II	**Air pollution modelling:** Transport and dispersion of air pollutants-Atmospheric stability-lapse rates and dispersion-plume behaviour-maximum mixing depth Estimating concentrations from point sources – dispersion modelling-Gaussian Plume Model – determination of dispersion parameters. Receptor models-Chemical Mass Balance (CMB) and Positive Matrix Factorization (PMF) models Box models- line source model-area source model-puff model	9
III	**Water quality modelling:** Historical development of water quality models River hydrology and flow– low flow analysis – Discharge of pollutants into rivers-Behaviour of conservative and nonconservative substances-transport-advection, diffusion and dispersion Dissolved oxygen in rivers, Streeter-Phelps equation, modification to Streeter-Phelps Equation Modelling lake water quality-mass balance for well mixed lakes-steady state solution-transfer function and residence time - dynamic state analysis (simple cases only)	9

IV	**Groundwater modelling:** Use of ground water models ground water flow modelling-Darcy's law-ground water flow equations for homogenous, heterogenous, isotropic and anisotropic conditions Mass transport of solutes-transport and transformation of contaminants in groundwater-the transformation processes- non-reactive processes, reactive processes-simulation of transport and transformation processes, formulation of the governing equations, initial and boundary conditions-solutions for simple cases. Seawater intrusion- Ghyben–Herzberg Principle – basic concepts and modelling	**10**
V	**Noise Modelling:** Environmental noise - noise generation mechanisms- need for noise modelling Modelling inputs-sound propagation factors- Equivalent Continuous Sound Pressure Level (Leq) Noise mapping methodology-modelling traffic noise	**9**
	Total hours	**45**

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
26CE362H	Ecological Engineering for Environmental Systems	PEC	3	0	0	3	2026

i) COURSE OBJECTIVES

This course introduces the application of ecological principles in the analysis, design, and management of environmental systems**,** integrating natural ecosystems with engineered interventions for sustainable development. Emphasis is placed on ecosystem structure and function, biodiversity conservation, pollutant impacts and the application of ecological principles in engineered and managed systems. Students are exposed to ecological engineering approaches such as constructed wetlands, phytoremediation and other nature-based solutions for wastewater treatment, pollution control, ecological restoration and climate resilience. The course also introduces field methods, biodiversity assessment, eco-informatics and emerging tools to evaluate system performance, resilience and sustainability, with a strong focus on Indian environmental systems and real-world case studies.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Explain the structure, function and dynamics of ecosystems and relate them to environmental systems and ecological engineering applications	Understand
CO2	Identify biodiversity patterns, hotspots and drivers of loss of biodiversity and interpret consequences for ecosystems	Apply
CO3	Apply ecological principles to design small-scale ecological engineering solutions for environmental systems	Apply
CO4	Identify impacts of common pollutants on ecosystem processes and recommend suitable eco-technological or nature-based remediation strategies for environmental systems	Apply
CO5	Use standard field, analytical methods and eco-informatics tools to assess biodiversity and interpret ecological data	Apply

iii) SYLLABUS

Ecosystem components, food chains/webs, ecological pyramids, productivity, ecosystem services, resilience, functional traits, social–ecological systems

Types and levels of biodiversity, hotspots, diversity metrics, drivers of biodiversity loss, conservation approaches, case studies

Community structure, niches, succession, species interactions, energy flow, nutrient budgets, stoichiometry, introduction to ecosystem modeling

Pollutant impacts, ecotoxicology, constructed wetlands, phytoremediation, biodegradation, eco-hydrology, nature-based solutions, climate resilience, policies, case studies

Field sampling methods, diversity indices, eco-informatics, GIS/remote sensing, eDNA, drones, adaptive management, case studies

iv) REFERENCES

1) Patrick C. Kangas, *Ecological Engineering: Principles and Practice*, 1st edition, ISBN: 978-1566705998, CRC Press Inc, 2003.
2) Eugene Odum and Gary Barrett., *Fundamentals of Ecology*, 5th edition, ISBN: 978-0534420666, Brooks/ Cole, 2004.
3) Charles J. Krebs, Ecological Methodology, 2nd edition, ISBN: 978-0321021731, Pearson Benjamin Cummings, 1999.
4) William J. Mitsch and Sven Erik Jorgensen, Ecological Engineering and Ecosystem Restoration, 2nd edition, ISBN: 978-0471332640, John Wiley & Sons, 2003
5) Rana.S.V.S., *Essentials of Ecology and Environmental Science*, Prentice Hall of India,New Delhi, 5th edition, 2013.
6) Etnier, C. and Guterstam, B., *Ecological Engineering for Wastewater Treatment*, Lewis Publishers, NewYork, 2nd edition, 1997.
7) Margaret A. Palmer, Joy B. Zedler and Donald A. Falk, Foundations of Restoration Ecology, 2nd edition, ISBN: 978-1610916981, Island Press, 2016.
8) W. Leal Filho, G. J. Nagy, and D. Y. Ayal, *Handbook of Nature-Based Solutions to Mitigation and Adaptation to Climate Change,* 1st edition, Springer, IBN: 978-3031349669, 2025.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Fundamentals of Ecology:** Ecosystem components- biotic and abiotic factors Trophic levels, food chains and food webs Ecological pyramids and productivity Ecosystem services (classification and valuation) Resilience, stability, functional traits Social–ecological systems and sustainability linkages Major natural and urban ecosystems of India	**8**
II	**Biodiversity:** Types and levels of biodiversity, biodiversity hotspots Biodiversity metrics –alpha, beta and gamma diversity Functional and phylogenetic diversity Drivers of biodiversity change- habitat loss, invasive species, overexploitation, pollution, climate change Impacts of biodiversity loss on ecosystem services Conservation prioritization, mitigation hierarchy, management	**9**

	approaches- Case studies in India	
III	**Community organization and Energy flow:** Community structure- species richness, evenness, dominance, indices for quantification Species interactions -competition, predation, mutualism, commensalism, parasitism Succession, niches, climax concepts Energy flow and biogeochemical cycles Introduction to ecosystem modeling (box models, Ecopath) and applications	**9**
IV	**Pollutants and Eco-technology for Environmental Management:** Impacts of pollutants on ecosystems- nutrients, pesticides, hydrocarbons, heavy metals, plastics/microplastics Principles of Ecotoxicology- dose-response relationships, bioaccumulation, biomagnification Constructed wetlands and Nature-based solutions for wastewater and stormwater treatment Phytoremediation, biodegradation and eco-hydrology approaches Climate-sensitive design of ecological engineering systems Case studies- ecological restoration and wastewater management (Indian and global contexts)	**10**
V	**Applied Ecology and Tools:** Field methods- quadrats, transects, trapping methods and mark- recapture techniques Bio-diversity indices- Shannon, Simpson, Pielou's evenness Eco-informatics tools- basic application of R/Python packages for biodiversity analysis and visualization GIS and remote sensing for habitat assessment and land-use change analysis Emerging tools- environmental DNA (eDNA), drones for ecological surveys Adaptive management-monitoring, feedback, adjustment cycle Case studies- ecological-engineering design or restoration	**9**
	Total hours	**45**

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
26CE362I	Air Pollution and Control Technologies	PEC	3	0	0	3	2026

i) COURSE OBJECTIVES

This course highlights the sources, effects and significance of different air pollutants. It also covers methods of sampling, analysis and control methods of specific air pollutants. The course is designed so as to enhance the knowledge in air pollution studies.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO 1	Identify the sources of outdoor and indoor air pollution and specific effects of air pollutants on health, vegetation, materials and atmosphere.	Apply
CO 2	Analyse the dynamics of air pollution dispersion under different atmospheric conditions	Analyse
CO 3	Discuss air quality standards, regulations and policies and their implications for industry and society	Apply
CO 4	Identify techniques for air sampling and analysis of particulate and gaseous air pollutants.	Apply
CO 5	Recommend suitable air pollution control methods/ devices/techniques based on the air pollutants present	Evaluate

iii) SYLLABUS

Air pollutants: Sources, Classification of air pollutants, Effects of air pollutants, Case studies on air pollution episodes, Behaviour and fate of air pollutants, Indoor air Pollution

Dynamics of air pollution dispersion: Effects of meteorology, Atmospheric stability, Transport and diffusion of stack emission, Stack plume patterns. Classification of air quality models, Gaussian plume model to determine the ground level concentration of air pollutant.

Air pollution legislation and regulation: National ambient air quality standards, Air quality emission standards, Air pollution indices, Economics of air pollution control.

Air sampling: Instruments for sampling ambient particulate and gaseous pollutants- Stack monitoring, Analysis of particulate and gaseous air pollutants

Control of air pollutants: Equipments for particulate and gaseous emission control, Automobile emission control techniques, Biological air pollution control techniques

iv) REFERENCES

1) Khare M., Sharma P., Kota S.H, Sumanth C., *Air Pollution Science Engineering and Management Fundamentals*, ISBN : 9780367750527, CRC Press, 1st edition, 2024
2) Rao, C.S., *Environmental Pollution Control Engineering*, New Age International Publishers, 3rd edition, 2018
3) Nevers N. D., *Air Pollution Control Engineering*, Mc. Graw Hill International, 2nd edition, 1999
4) Aruthur C. Stern, *Air Pollution, Volume1- Air Pollutants, their Transformation and Transport*, Academic Press, 3rd edition, 2006
5) Wark K., Warner C. F. and Davis W., *Air Pollution Its Origin and Control*, 3rd edition, Harper and Row, New York
6) Rao M. N., *Air Pollution*, Tata McGraw Hill, New Delhi, 2018
7) Griffin R. D., *Principles of Air Quality Management*, CRC Press, Boca Raton, USA, 2nd edition, 2020
8) Boubel R. W., Fox D.L., Turner D.B., Stern A. C., *Fundamentals of Air Pollution*, Academic Press, 3rd edition, 1994

v) COURSE PLAN

Module	Contents	No. of hours
I	**Air pollutants:** Sources-Industrial and vehicular sources of air pollution, Classification of air pollutants, Effects of air pollutants on health, vegetation, materials & atmosphere Case studies on air pollution episodes, Behaviour and fate of air pollutants. Indoor air pollution- Sources, types and control of Indoor pollutants, Sick building syndrome	9
II	**Dynamics of air pollution dispersion:** Effects of meteorology, Wind profile, Topographic effects, temperature profile, Lapse rate, Inversion, Atmospheric stability, Mixing height, Transport and diffusion of stack emission, Stack plume patterns. Classification of air quality models, Gaussian plume model to determine the ground level concentration of air pollutantassumptions and limitations, Effective stack height. indoor air pollution Modelling	10
III	**Air pollution legislation and regulation:** National ambient air quality standards, Air quality emission standards, Air pollution indices Economics of air pollution control	8

IV	**Air sampling**: Instruments for sampling ambient particulate and gaseous pollutants- Principles and working , Stack monitoring Analysis of particulate and gaseous air pollutants.	**9**
V	**Control of air pollutants:** Factors affecting the selection of control equipment, Equipments for particulate and gaseous emission control- sulphur dioxide, nitrogen oxides, hydrocarbons Automobile emission control techniques Biological air pollution control techniques, Bioscrubbers.	**9**
	Total hours	**45**

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
26CE362J	Advanced Wastewater Treatment Technologies	PEC	3	0	0	3	2026

i) COURSE OBJECTIVES

This course aims to provide advanced knowledge of physico-chemical and biological processes used in wastewater treatment beyond conventional methods. It enables students to evaluate and select appropriate advanced treatment technologies based on wastewater characteristics and treatment goals. The course also introduces membrane-based and bio-electrochemical systems for contaminant removal and resource recovery, while emphasizing process performance, fouling, energy demand and sustainability considerations.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO 1	Compare and appraise conventional and advanced techniques for the treatment of wastewater	Apply
CO 2	Choose the most suitable sorption technique based on the contaminant characteristics	Apply
CO 3	Identify appropriate advanced oxidation techniques based on the nature of contaminants.	Apply
CO 4	Compare the performance of various filtration techniques used for the treatment of wastewater	Analyse
CO 5	Identify the applications of membrane bioreactor (MBR) technology and microbial fuel cell (MFC)	Apply

iii) SYLLABUS

Introduction- Limitations of conventional wastewater treatment methods, Purpose and benefits of advanced wastewater treatment. Chemical clarification, Electrocoagulation, Demineralization, ion exchange, Ammonia stripping

Sorption Techniques - Types of sorbents, Sorption kinetics and isotherm models, Activated carbon adsorption and regeneration, Biosorption, Photo-catalytic adsorbents

Advanced oxidation- UV/Hydrogen peroxide process, Electro-chemical Oxidation processes, Ozone based processes, Wet Air Oxidation (WAO), Fenton and photo-fenton process, Catalytic oxidation processes

Filtration, Microfiltration, Ultrafiltration, Nanofiltration, Reverse Osmosis, Electrodialysis, Pervaporation

Membrane reactors- Membrane Module / Element designs, Membrane System components, Design of Membrane systems, Membrane Bioreactors, Microbial Fuel Cell

iv) REFERENCES

1) Metcalf & Eddy, George Tchobanoglous, Franklin Burton and H. David Stensel, *Wastewater Engineering; Treatment and Reuse*, McGraw Hill Education, 4th edition, 2017
2) Arcadio P. Sincero and Gregoria A. Sincero, *Environmental Engineering: A Design Approach*, Pearson Education Services Pvt. Ltd., 2nd edition, 2016
3) Hammer, *Water and Wastewater Technology*, John Wiley and Sons, New York, 7th edition, 2011
4) Ronald L. Droste, *Theory and practice of water and wastewater treatment*, John Willy and sons (ASIA) Pvt. Ltd., 2nd edition, 2018
5) Simon Parsons, *Advanced oxidation processes for water and wastewater treatment,* IWA Publishing, 2004
6) Serpil Edebali, *Advanced Sorption process application*, Intechopen Publishing, 2019
7) Water Environment Federation (WEF), *Membrane Systems for Wastewater Treatment*, McGraw-Hill, USA, 1st edition, 2005
8) Mulder M., *Basic Principle of Membrane Technology*, Kluwer Academic Publishers, 2nd edition, 1996
9) Noble, R.D. and Stern, S.A., *Membrane Separations Technology: Principles and Applications*, Elservier, 1995

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Advanced Treatment Systems:** Limitations of conventional wastewater treatment methods, Purpose and benefits of advanced wastewater treatment Chemical clarification, Electrocoagulation, Demineralization, Ion exchange, Ammonia stripping, Introduction to emerging contaminants	9
II	**Sorption and Advanced Adsorbent Technologies:** Types of sorbents, Sorption kinetics and isotherm models Activated carbon – manufacture, properties, adsorption and regeneration Biosorption- Nanoadsorbents and Photo-catalytic adsorbents- Applications for removal of nutrients, heavy metals and organics, Desorption and material recovery	9

III	**Advanced oxidation Processes:** UV/H_2O_2 – Ozonation – Electrochemical oxidation – Wet Air Oxidation – Fenton and Photo-Fenton – Catalytic oxidation – Radiation-based processes – Reaction mechanisms – Energy requirements – Formation of by-products Comparative evaluation of AOPs for refractory pollutants	**9**
IV	**Membrane Filtration and Separation Processes:** Depth and surface filtration -Filter performance and operational problems, Microfiltration, Ultrafiltration, Nanofiltration, Reverse Osmosis, Electrodialysis, Pervaporation, Membrane materials, Transport mechanisms, Fouling- causes, models and control strategies, Process selection.	**9**
V	**Integrated Membrane Reactors and Bio-electrochemical systems:** Membrane manufacture – Module configurations, System components, Design concepts Membrane Bioreactors (MBR)- Biotreatment fundamentals, Configurations, Biomass Separation, MBR Principles, Fouling and Fouling Control, Design considerations Microbial Fuel Cell (MFC): Principle, components, energy recovery, applications, limitations Hybrid systems- AOP-MBR, Adsorption-MBR	**9**
	Total hours	**45**

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
26CE362K	Environmental Biotechnology and Bioremediation	PEC	3	0	0	3	2026

i) COURSE OBJECTIVES

This course highlights the significance of molecular biology in environmental monitoring. It also outlines the importance of biotechnology in environmental applications like biodegradation and bioremediation.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO 1	Apply the concepts of molecular biology in contaminant remediation	Apply
CO 2	Apply the microbiological processes in waste treatment	Apply
CO 3	Analyse the process of biodegradation of organic pollutants	Analyse
CO 4	Identify appropriate strategies for bioremediation based on the nature of contaminants	Apply
CO 5	Apply biotechnological practices in environmental engineering	Apply

iii) SYLLABUS

Introduction to Molecular Biology: Introduction to microbial genetics - genetic code, DNA replication and protein synthesis. Recombinant DNA technology -vectors, restriction enzymes. Applications of Genetic engineering

Waste management: Microbiology of Nitrification and denitrification. Aerobic and anaerobic process microbiology. Immobilisation of microbial cells and enzymes

Biodegradation: Microbes and organic pollutants, Relationship between contaminant structures, Aerobic vs anaerobic degradation. Biodegradation of hydrocarbons, phenols, PAH, PCB, synthetic detergents, Salicylate, organophosphates, pesticides and herbicides

Bioremediation: Bioremediation- in situ bioremediation- ex situ bioremediation Phytoremediation, phycoremediation , mycoremediation

Applications of Biotechnology: Genetically engineered microbes in biotreatment of wastes- Environmental applications of molecular techniques. Biosurfactants , biomining, biosorption, Biofuels - biohydrogen , bioethanol , microbial fuel cell

iv) REFERENCES

1) Raina. M. Maier, Ian L. Pepper & Charles P. Gebra, *Environmental Microbiology*, Elsevier India Pvt ltd, New Delhi, 2nd edition, 2008
2) P.D.Sharma, *Microbiology*, Rastogi publications, Meerut, 4th edition, 2019
3) A.K Chatterji ,*Introduction to Environmental Biotechnology*, PHI Learning Pvt Ltd, New Delhi , 3rd Edition, 2011
4) Gabriel Bitton ,*Wastewater Microbiology* , John Wiley & Sons, 3rd edition ,2005
5) Gareth M. Evans and Judith C. Furlong, *Environmental Biotechnology Theory and Application*, John Wiley & Sons, 2nd edition , 2012

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Molecular Biology:** Introduction to microbial genetics - genetic code, DNA replication and protein synthesis Recombinant DNA technology-vectors ,restriction enzymes Applications of Genetic engineering	9
II	**Waste management:** Microbiology of Nitrification and denitrification Aerobic and anaerobic process microbiology-activated sludge process, aerobic stabilisation ponds, trickling filters, composting, vermicomposting and methanogenesis Immobilisation of microbial cells and enzymes, immobilised enzymes in wastewater treatment process	9
III	**Biodegradation:** Microbes and organic pollutants, Relationship between contaminant structures, toxicity and biodegradability, environmental factors affecting biodegradation, Aerobic vs anaerobic degradation Biodegradation of hydrocarbons, phenols, PAH, PCB, synthetic detergents, Salicylate, organophosphates, pesticides and herbicides	9
IV	**Bioremediation:** Bioremediation- in situ bioremediation-bioventing, water circulation system biosparging , Intrinsic in-situ bioremediation Ex-situ bioremediation- land farming ,composting, biopiles and bioreactors Phyto-remediation , phyco-remediation , myco-remediation	9
V	**Applications of Biotechnology:** Genetically engineered microbes in biotreatment of wastes. Release of genetically engineered microbes and environmental risks.	9

	Environmental applications of molecular techniques – PCR, DNA Probe, FISH. Toxicity assay using microorganisms – Microtox assay Biosurfactants , biomining ,biosorption, Biofuels – biohydrogen, bioethanol , microbial fuel cell	
	Total Hrs.	**45**

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
26CE362L	Environmental Hydrology	PEC	3	0	0	3	2026

i) COURSE OBJECTIVES

This course aims to provide introduction to the fundamental hydrological concepts and their applications with a focus on the concepts required for hydrological modelling over varying spatial (catchment to global) and temporal scales.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO 1	Explain the complex structure of environmental hydrologic systems.	Understand
CO 2	Mathematically formulate processes in the hydrologic cycle in different environments and solve problems dealing with water balance.	Apply
CO 3	Make use of the concepts of hydrologic analysis in engineering designs.	Apply
CO 4	Interpret the results for decision support and management.	Evaluate

iii) SYLLABUS

Introduction to Hydrological Processes

Hydrologic Analysis and Design

Principles of Groundwater flow

Wells: Open wells, Tube wells, Well loss, Well development

Basin Management & Pollution

iv) REFERENCES

1) Ojha C. S. P., Berndtsson, R., & Bhunya, P., *Engineering hydrology*, Oxford University Press, 2008
2) Mc Cuen, R. H., *Hydrologic analysis and design*, Prentice Hall, Eaglewood Cliffs, New Jersey, 4th edition, 2016
3) Chow V.T., D.R. Maidment and L.W. Mays, *Applied Hydrology*, McGraw Hill Book company, Singapore, 2017
4) Singh, V.P., *Elementary Hydrology*, Prentice Hall of India, New Delhi, 1994.
5) Todd, David Keith, and Larry W. Mays, *Groundwater hydrology*, John Wiley & Sons, 3rd edition, 2005
6) Subramanya K., *Engineering Hydrology*, Tata Mcgraw Hill, Newdelhi,5th edition, 2020
7) Raghunath H.M., *Hydrology*, H.M Wiley Eastern Ltd, NewDelhi, 3rd edition, 2015

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Hydrological Processes:** Fundamental Hydrology- Hydrological cycle-components of hydrologic Cycle-Systems concept- Hydrologic system model, Hydrologic model Classification-Water Balance Precipitation- Rainfall characteristics- types and forms of precipitation- Rainfall data and its processing- frequency analysis-probability distribution and its application hydrology-Development of a design storm, Depth-Area Adjustment, Average areal rainfall, Estimating missing rainfall data Infiltration- Process, Factors affecting infiltration, Measurement, Modelling – Richard's equation, Green-Ampt model Evaporation and Transpiration–Factors affecting evaporation, Measurement, Transpiration, Evapotranspiration, Penman equation	10
II	**Hydrologic Analysis & Design:** Hydrograph analysis – Baseflow separation, Estimation of initial abstraction, Separation of losses and rainfall excess, separation of losses using infiltration capacity curves, Introduction to unit hydrograph, Rainfall excess reciprocal method, S-hydrograph method. Design precipitation Depth -Intensity Duration- Frequency relationships-Design Hyetographs from Storm Event Analysis Rainfall-Runoff Relationships -Total runoff in relation to total rainfall- Relationships for Peak Runoff Computations- Linear and Nonlinear Rainfall- Runoff Relationship-Extension of Stream Flow Record Flood Routing- Channel Routing- Basic Equations- Muskingum Method of Routing	9
III	**Principles of groundwater flow:** Storage coefficients, Darcy's law, permeability, determination of hydraulic conductivity Well hydraulics- steady radial flow to a well, unsteady radial flow in confined, unconfined and leaky aquifers, multiple well systems, specific capacity	9

IV	**Wells:** Open wells – Design of open well – yield test- Methods of construction-dug wells Tube wells–design-screened wells-gravel packed wells selection of screen size-yield of a well Well loss- determination of well loss by step pumping method Well development- testing wells for yield- failure of tube wells. Cavity wells and Infiltration galleries	**9**
V	**Basin management and Pollution:** Concept of basin management- Need, Various Aspects and Approaches of Planning and Management Pollution of ground water, salt water intrusion in aquifers, Ghyben- Herzberg relation Geophysical exploration techniques, artificial recharge of ground water	**8**
	Total Hrs.	**45**

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
26CE362M	Contaminant Transport and Remediation	PEC	3	0	0	3	2026

i) COURSE OBJECTIVES

Goal of this course is to learn the mechanism of contaminant transport and estimation of extent of contamination by modelling and for selecting appropriate remedial measures.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO 1	Apply the fundamental concepts of groundwater flow, transport and contamination in determining the extent of soil and groundwater contamination	Apply
CO 2	Identify the governing processes and factors controlling transport and fate of contaminants in soil and groundwater	Apply
CO 3	Make use of softwares for groundwater and contaminant transport modeling	Apply
CO 4	Identify most suitable remediation technologies for addressing groundwater contamination problems	Apply

iii) SYLLABUS

Characteristics of unsaturated zone- Introduction to water movement in the subsurface, Types of aquifers, Steady State and transient flow, Ground water and well hydraulics

Groundwater resource- Resource evaluation, Exploration of Aquifers, Saline water intrusion in coastal aquifers

Groundwater contamination- Sources of Groundwater Contamination, Contaminant transport through porous media, Advection and Dispersion transport, Solute transport, Reaction and transport of trace metals

Groundwater and transport modelling- Groundwater modelling, Contaminant transport modeling, Introduction to Groundwater Modelling softwares

Remediation measures

iv) REFERENCES

1) Hou D., *Sustainable Remediation of Contaminated Soil and Groundwater: Materials, Processes, and Assessment,* Elsevier, ISBN: 978-0128185108**,** 2020
2) Cheremisinoff, N.P., Groundwater *Remediation: A Practical Guide for Environmental Engineers and Scientists,* Wiley, ISBN: 978-1119371598, 2017
3) Ok, Y.S, Rinklebe J., Hou, D.,Tsang, D. C.W., Tack, F.M.G, *Soil and Groundwater Remediation Technologies*, CRC Press, ISBN: 978-0367204570, 2020

4) Randall J. Charbeneau, *Ground water Hydraulics and Pollutant Transport*, 1st edition, 2006
5) D. K. Todd and L. W. Mays, *Groundwater*, John Wiley & Sons, Inc., 3rd edition, 2004
6) C. W. Fetter, *Applied Hydrogeology,* Prentice Hall, Inc., 4th edition, 2001
7) C. W. Fetter*, Contaminant Hydrogeology*, Waveland Press, 2nd edition, 2008
8) P. A. Domenico and F. W. Schwartz, *Physical and Chemical Hydrogeology*, , John Wiley & Sons, Inc., 2nd edition,1998
9) F. W. Schwartz and H. Zhang, *Fundamentals of Groundwater*, John Wiley & Sons, Inc., 1st edition, 2003
10) A. K. Rastogi, *Numerical Groundwater Hydrology*, Penram International Publishing (India) Pvt. Ltd., 2007
11) VedatBatu, *Applied Flow and Solute Transport Modelling in Aquifers*, Taylor and Francis/ CRC Press, 1st edition, 2006
12) E. Scott Bair, Terry D. Lahm, *Practical Problems in Groundwater Hydrology*, Pearson Prentice Hall, 1st edition, 2006

v) COURSE PLAN

Module	Contents	No. of hours
I	**Characteristics of unsaturated zone:** Introduction to water movement in the subsurface - origin, age, distribution, types of aquifers. Darcy's law, hydraulic head and fluid potential, hydraulic conductivity and permeability, heterogeneity and anisotropy of hydraulic conductivity, porosity and void ratio, compressibility and effective stress, transmissivity and storativity. Steady State and transient flow - formulation of the governing equations, limitations of the Darcian approach. Ground water and well hydraulics - steady flow to a well fully penetrating an aquifer (confined and unconfined), unsteady radial flow to a well fully penetrating an aquifer (confined, unconfined and leaky), effect of well bore storage. Equations of groundwater flow – Problems, Limitations of Darcian Approach-hydrodynamic dispersion.	**9**
II	**Groundwater resource:** Resource evaluation- development of ground water resources-Exploration of Aquifers-the response of ideal aquifers to pumping- Measurement of parameters-Laboratory tests Multiple well systems, partially penetrating wells, bounded aquifers, characteristic well losses, specific capacity. Slug tests Saline water intrusion in coastal aquifers: occurrence, shape and structure of the interface, upconing.	**9**

III	**Groundwater contamination:** Introduction to groundwater contamination, Sources of Groundwater Contamination, Contaminant transport through porous media, Advection and Dispersion transport, 2-D / 3-D Advection Dispersion equation for contaminant- estimation of dispersion coefficient (Problems) Chemical Reactions - Equilibrium controlled sorption - Estimation of retardation factor by batch, column and field study Solute transport- nonreactive constituents in homogeneous media, transport in fracture media, hydrochemical behaviour of contaminants. Reactive Transport – First order decay, Decay and Adsorption – Ion exchange reactions, Reaction and Transport of Trace Metals	**9**
IV	**Groundwater and transport modelling:** Groundwater modelling – Inverse modelling in groundwater – Artificial recharge of aquifers - Groundwater budget - Groundwater resource estimation. Contaminant transport modelling - Model development, model input parameters, initial and boundary conditions, model calibration, model validation Introduction to Groundwater modelling software - USGS-MOC model, VISUAL MODFLOW/MT3DMS/FEFLOW Sensitivity analysis and case study for leachate transport	**9**
V	**Remediation measures:** Control measures of saline water intrusion, Artificial recharge and induced infiltration Soil methods- Soil washing, Soil Vapour extraction, Subsurface barriers, Soil flushing, Stabilization, Bioremediation, Bioventing, Phytoremediation, Encapsulation, Aeration, Natural attenuation Groundwater methods- Air sparging, Pump and treat method, Groundwater circulation wells, Passive reactive barrier, bioslurping, biosparging, UV oxidation	**9**
	Total Hrs.	**45**

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
26CE362N	Environmental Toxicology	PEC	3	0	0	3	2026

i) COURSE OBJECTIVES

This course introduces students to the effects of various chemicals and toxicants on the ecosystems and the environment. The course also gives an overview of the biochemical mechanisms related with toxicity and examines their impact at the population and community level. This helps the students to create a thorough knowledge about research related activities in Ecotoxicology and Environmental Engineering

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Identify the effects of various chemicals on Environment.	Apply
CO2	Analyse various toxicants related with soil, water and air.	Analyse
CO3	Identify various health hazards due to toxicants.	Apply
CO4	Identify various industrial chemicals and its effects on ecosystems.	Apply
CO5	Analyse various biochemical mechanisms related with toxicity.	Analyse

iii) SYLLABUS

Introduction to Toxicology: Definition and scope. Toxicity testing, General awareness about Toxicity symbols

Pesticides, herbicides and insecticides

Environmental effects of toxicants: Bioaccumulation- Environmental degradation of pesticides – photolysis and microbial degradation. Bio-transformation, and bio-magnification

Toxic metals and chemicals in the environment

Antioxidants and oxidative stress

iv) REFERENCES

1) Jorgenson S.E., Halling S, B., Mahler, H., *Handbook of Estimation Methods in Ecotoxicology and Environmental Chemistry*, Lewis publishers, CRC press, LLC Boca Raton, 1st edition, 1998

2) Jorgensen S.E., *Fundamentals of Ecological Modelling*- Applications in Environmental Management and Research, Elsevier Science B.V., Amsterdam, 4th edition, 2011

3) Jorgensen S.E., Nielsen S.N., Jorgensen L.A., *Handbook of Ecological Parameters and Ecotoxicology*, Elsevier science Publishers B.V., Amsterdam, 2011

4) Moriarty F., *Ecotoxicology; The Study of Pollutants in Ecosystems*, Academic Press

Ltd., London, 1998

5) Newman M.C., Jagoe C.H., *Ecotoxicology ; A Hierarchial Treatment*, CRC Press Inc. Lewis publishers, Boca raton, 1996

6) Richardson M., *Environmental Toxicology Assessment*, Taylor and Francis Ltd, London, 1995

v) COURSE PLAN

Module	Contents	Hours
I	**Introduction to Ecotoxicology:** Toxicology- definition and scope, acute and chronic toxicity, selective toxicity, synergism and antagonism Toxicity testing- Bioassay – definition, purpose, criteria for selection of test organism methodology, estimation of LC50 and LD50, limitation and importance of bioassay, acute toxicity (single), sub acute toxicity, chronic toxicity Teratogenicity, carcinogenicity and mutagenicity. General awareness about Toxicity symbols, Pesticide Toxicity Labels, Fire diamonds (NFPA 704 system)	9
II	**Pesticides, herbicides and insecticides:** Pesticides – classification based on target organism and chemical structures (organochlorines, organophosphorus, carbamates and pyrethroids) Mode of action of herbicides (photosynthesis inhibition and amino acid biosynthesis inhibition), fungicides (Ergosterol and biosynthesis inhibition) and insecticides (cholinesterase inhibition, chitin synthesis inhibitors) Toxic organic compounds- PCBs, PAHs, PBDEs, Dioxins and Furans – origin and adverse effects	9
III	**Environmental effects of toxicants:** Bioaccumulation- Health hazards due to hexachlorobenzene, polychlorinated biphenyls, Dioxins and DDT Environmental degradation of pesticides – photolysis and microbial degradation Bio-transformation and bio-magnification- Principles, receptor sites absorption and storage of xenobiotics, types of bio- transformations, Influence of ecological factors on the effects of toxicity	9

IV	**Toxic metals and chemicals in the Environment:** Industrial chemicals (Ammonia, Formaldehyde, Phosgene, Hydrogen cyanide, Sulphuric acid, Chlorine, Ethylene oxide Food additives (Aspartame, Monosodium glutamate, sodium nitrite, Trans Fat, butylated hydroxytoluene, Propyl Gallate, Tartrazine) Source of contaminants, fate, effects and its action in target organs, Normal and abnormal responses to xenobiotics Toxic metals and chemicals in the environment and biochemical aspects of As, Cd, Pb, Hg, CO, O_3, PAN. Radiation pollution and toxicity – origin and health hazards, Radon pollution, Radiation symbol	**9**
V	**Antioxidants and oxidative stress:** Lipid peroxidation – Introduction to the process of lipid peroxidation, ROS & RNS, Mechanism of reactive oxygen species production, key role of superoxide anion radical, Hydrogen peroxide and hydroxyl radicals in toxicity of xenobiotics Oxidative stress – definition of oxidative stress, Toxicological consequences of oxidative stress, Oxidative stress and protein damage, Oxidative stress and DNA damage, Oxidative stress and lipid damage, Antioxidative defence mechanisms Enzymatic and Non enzymatic antioxidants, Role of glutathione, Superoxide dismutase, Metallothionein and αtocopherol as antioxidants	**9**
	Total hours	**45**

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
26CE362O	Solid and Hazardous Waste Management	PEC	3	0	0	3	2026

i) COURSE OBJECTIVES

Solid and Hazardous Waste Management covers the concepts related to various solid wastes, their origin, characteristics, treatment and the legal aspects. This course also addresses the various functional elements that constitute the integrated solid waste management systems. This provides safe recycling and disposal options for special wastes that may pose harm to the environment and /or to public health and safety. This course also makes the students aware of advanced principles related to the separation, processing and transform technologies of solid and hazardous Wastes.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Identify the sources, types and characteristics of solid waste	Apply
CO2	Evaluate the different methods for collection and storage of solid waste	Evaluate
CO3	Assess the adequacy of the different transfer and transportation means and methods	Evaluate
CO4	Apply guidelines and standard procedures in the design of landfills and integrated waste management facilities	Apply
CO5	Identify suitable disposal methods for hazardous and biomedical wastes	Apply

iii) SYLLABUS

Solid waste: Definitions, Sources and types of solid waste
Legislation for Solid waste management
Storage and handling of solid waste
Collection and transport of solid wastes
Separation, Processing and Transformation of Solid Waste
Landfills, Hazardous waste management

iv) REFERENCES

1) Howard S. Peavy, Donald R. Rowe, George Tchobanoglous, *Environmental Engineering,* McGraw Hill Education, 1st edition*, 2017*
2) George Tchobanoglous, Hilary Theisen and Samuel A, Vigil, *Integrated Solid Waste Management*, McGraw Hill Education, New York, 2014
3) George Tchobanoglous and Frank Kreith, *Handbook of Solid Waste Management*, McGraw hill publications, New york, 2nd edition, 2002
4) *Manual on Municipal Solid waste management*, Central Public Health and Environmental

Engineering Organization, Government of India, New Delhi, 2016
5) Vesilind P. A., Worrell W., Reinhart D., *Solid Waste Engineering*, Brooks/Cole Thomson Learning Inc., 2nd edition, 2010
6) John Pichtel, *Waste Management Practices: Municipal, Hazardous and Industrial*, CRC Press, 2nd edition, 2014
7) Qian X, Koerner R. M. and Gray D. H., *Geotechnical Aspects of Landfill Design and Construction*, Prentice Hall, 1st edition, 2002
8) LaGrega M.D., Buckingham P.L. and Evans J.C., *Hazardous Waste Management*, Waveland Pr Inc., 2010, Reissue Edition
9) Townsend, Timothy G., Jon Powell, Pradeep Jain, Qiyong Xu, Thabet Tolaymat, and Debra Reinhart. Sustainable practices for landfill design and operation. Springer, 2015
10) Tchobanoglous, G., Hilary Theisen and Samuel Vigil. Integrated solid waste management: engineering principles and management issues, McGraw Hill, 2014.

(v) COURSE PLAN

Module	Contents	No. of hours
I	**Solid waste:** Definition of solid waste, Waste generation in a technological society, Solid waste management- an overview Major legislations, Monitoring responsibilities Sources and types of solid waste, Sampling and characterization, Properties of solid waste, Determination of composition of MSW, Energy content. Solid waste generation, Storage and handling of solid waste Factors affecting waste generation and composition.	9
II	**Collection and transport of solid wastes:** Collection and transport of solid waste-Collection of Solid waste- Type of waste collection systems, analysis of collection system-Collection routes, Alternative techniques for collection system. Transfer and Transport- Need for transfer operation, transport means and methods, transfer station types and design requirements	9
III	**Separation, Processing and Transformation of Solid waste**: Unit operations used for separation and processing, Materials Recovery facilities Processing techniques- mechanical volume reduction, mechanical size reduction, chemical volume reduction Waste transformation through combustion and composting, Aerobic composting, Anaerobic methods for materials recovery and treatment. Urban mining- recovery of valuable materials from waste Recycling of plastic materials and metals. Energy recovery options – Incinerators, RDF Case studies on smart and sustainable solid waste management systems	9

IV	**Landfills:** Landfills- Site selection, design and operation Drainage and leachate collection systems – requirements and technical solutions, designated waste landfill remediation Landfill gas, Integrated waste management facilities, Landfill closure	**9**
V	**Hazardous waste management**: Hazardous waste - Definition and Identification, Classification, Regulations, Handling and Storage, Collection, Transportation, Stabilization and Solidification, Thermal methods, Secure Landfill. Waste minimization and resource recovery, Treatment and remedial actions, Physico-chemical processes, Biological methods. Biomedical waste disposal- Solidification, chemical fixation and encapsulation, incineration. Hazardous waste landfills- Site selection, design and operation – remediation of hazardous waste disposal sites.	**9**
	Total hours	**45**

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
26CE362P	Computational Methods for Environmental Engineering	PEC	3	0	0	3	2026

i) COURSE OBJECTIVES

This course focuses on computational and numerical methods essential for solving environmental science and engineering problems. It emphasizes the formulation of environmental models, numerical solution techniques, error analysis and interpretation of results. The course integrates mathematical foundations with practical applications in air quality, water resources, climate systems and environmental data analysis using modern computational tools.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Formulate environmental science and engineering problems suitable for numerical and computational modelling.	Apply
CO2	Apply numerical methods to solve algebraic equations and systems arising in environmental applications.	Apply
CO3	Implement numerical techniques for interpolation, integration, and environmental data analysis.	Apply
CO4	Solve ordinary and partial differential equations relevant to environmental transport and processes.	Apply
CO5	Analyse numerical accuracy, stability and reliability of computational models used in environmental studies.	Analyse

iii) SYLLABUS

Computational foundations and algebraic systems in environmental modeling
Linear systems and Eigenvalue problems in environmental applications
Interpolation, approximation and numerical integration for environmental data
Numerical solution of ordinary differential equations in environmental systems
Partial differential equations and advanced environmental applications

iv) REFERENCES

1) Chapra S.C. and Canale R.P., *Numerical Methods for Engineers*, McGraw Hill Education, 8th edition, ISBN: 978-1259918806,2021
2) Chapra S.C., *Applied Numerical Methods with MATLAB for Engineers and Scientists*, McGraw Hill Education, 4th edition, ISBN: 978-1259957195, 2020
3) Burden R.L. and Faires, J.D., *Numerical Analysis*, Cengage Learning, 10th edition, ISBN: 978-1305258651, 2016

4) Jain M.K., Iyengar S.R.K. and Jain R.K., *Numerical Methods for Scientific and Engineering Computation,* New Age International, 6th edition, ISBN: 978-8122420012, 2012

5) Logan J.D., *Applied Mathematics*, Wiley, 3rd edition, ISBN: 978-0470889427, 2013

6) Rao S.S., *Engineering Optimization- Theory and Practice*, Wiley, 5th edition, ISBN: 978-1119450966, 2019

7) Strang, G., *Computational Science and Engineering,* 2nd edition, Wellesley-Cambridge Press, Wellesley, ISBN: 978-0961408817, 2019

8) Press, W. H., Teukolsky, S. A., Vetterling, W. T., and Flannery, B. P., *Numerical Recipes: The Art of Scientific Computing,* 3rd Edition, Cambridge University Press, Cambridge, ISBN: 978-0521880688, 2007

v) COURSE PLAN

Module	Contents	Hours
I	**Computational foundations and Algebraic systems in Environmental Modelling:** Role of computational methods in environmental science and engineering, Types of numerical errors- truncation, round-off and propagation Accuracy, precision, stability, convergence and conditioning Floating-point arithmetic and computational limitations Root-finding methods with environmental examples- Bisection method, Newton–Raphson method Solution of small systems of linear equations- Gaussian elimination, Iterative methods (Jacobi method – introduction) Formulation of simple environmental balance equations (mass and energy)	9
II	**Linear systems and Eigenvalue problems in Environmental applications:** Solution of large systems of linear equations- LU decomposition, Gauss–Seidel method Convergence criteria and computational efficiency Eigenvalue problems-Power method Applications in environmental systems- Compartment models, Stability of ecological and environmental systems Case studies from air and water quality modelling	9
III	**Interpolation, Approximation and Numerical integration for environmental data :** Interpolation techniques- Lagrange and Newton interpolation Least squares approximation and regression analysis Numerical differentiation of environmental data Numerical integration techniques- Trapezoidal rule, Simpson's rules, Gaussian quadrature	9

	Applications to rainfall analysis, pollutant load estimation, and climate data	
IV	**Numerical solution of ordinary differential equations in environmental systems:** Initial value problems for environmental processes- Euler and Modified Euler methods, Runge–Kutta methods Stability and step-size considerations Boundary value problems- Finite difference method Applications to Water quality modeling, Population dynamics, Biogeochemical cycles	**9**
V	**Partial differential equations and advanced environmental applications:** Introduction to partial differential equations in environmental science, Finite difference solution of Advection–diffusion equation, Heat transport equation Basics of numerical optimization in environmental management Introduction to Monte Carlo simulation for uncertainty analysis Case studies in air pollution, groundwater flow, and climate modelling	**9**
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of introduction
26CE062A	Data Science and ML in Civil Engineering	PEC	3	0	0	3	2026

i) COURSE OBJECTIVES

Goal of this course is to introduce the applications of Artificial Intelligence (AI) in Civil Engineering by covering foundational concepts of artificial intelligence and machine learning techniques, with a focus on real-world applications, while the project component enhances practical skills to solve domain-specific challenges using AI, and to obtain comprehensive knowledge of various tools and techniques for data transformation and visualization, to learn probability and probabilistic models of data science, and to learn basic statistics and hypothesis testing for specific problems.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Apply exploratory data analysis and create insightful visualisations to identify patterns	Apply
CO2	Make use of statistical foundations of data science and analyse the degree of certainty of predictions using statistical test and models	Analyse
CO3	Apply the basic probability principles and techniques in data science	Apply
CO4	Apply Machine learning techniques in solving problems in Civil Engineering.	Apply

iii) SYLLABUS

Data Science process, Memorization methods, Unsupervised models, Univariate data exploration, Data visualisation, Prediction and filtering, Probability theory and Statistics, Machine Learning Basics.

iv) REFERENCES

1) Russell, S., & Norvig, P., *Artificial Intelligence: A Modern Approach*, 4th edition, Pearson Education, 2022.
2) Alpaydin, E., *Introduction to Machine Learning*, 4th Edition, MIT Press, 2020.
3) Mandal, U. K., & Saha, S. *AI and Data Analytics in Civil Engineering*, 1st edition, CRC Press, 2023.
4) Nathan Yau, *Visualize This: The Flowing Data Guide to Design, Visualization and Statistics,* Wiley, 2011
5) Nina Zumel, John Mount, *Practical Data Science with R*, Manning Publications, 2014

v) COURSE PLAN

Module	Contents	No. of hours
I	**Data Science process** - Roles and stages in a data science project, working with files and databases, Exploring and managing data. Exploratory Data Analysis. Exploring Univariate Data - Histograms - Stem-and Leaf Quantile Based Plots - Continuous Distributions - Quantile Plots- QQ Plot- Box Plots	**9**
II	**Probability Concepts** -Axioms of Probability - Conditional Probability and Independence - Bayes Theorem - Expectation - Mean and Variance Skewness Kurtosis; Common Distributions-Binomial, Poisson, Uniform, Normal, Exponential.	**9**
III	**Introduction to Statistics** - Sampling, Sample Means and Sample variance sample moments, covariance, correlation, Sampling Distributions - Parameter Estimation Bias - Mean Squared Error - Relative Efficiency - Standard Error - Maximum Likelihood Estimation. Comparing Two Samples - A/B Testing - ANOVA.	**9**
IV	**Introduction to Machine Learning**: Basics of Machine Learning (ML)- types of Machine Learning Systems and Challenges. **Supervised learning**- Regression techniques- Linear Regression, Logistic regression, Multiple linear regression; Polynomial Regression (concept only), Decision Tree Regression (concept only). Classification techniques (Basic concept only)- Support Vector Machines. Application in prediction.	**9**
V	**Unsupervised learning-**Dimensionality Reduction - Need, Principal Component Analysis, Clustering: Basic concepts, Types of Clustering, similarity/dissimilarity measures. Clustering Algorithm-K-means algorithm, Hierarchical clustering (concepts only), Density-based clustering (concept only). Performance Evaluation Measures - clustering. Relevant Case studies.	**9**
	Total	**45 hours**

RESEARCH METHODOLOGY AND IPR (AC)

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
26AC061A	Research Methodology and IPR	AC	2	0	0	0	2026

i) COURSE OBJECTIVES

This course is intended to prepare the M. Tech students to carry out their dissertation/ research project work effectively, with a research bias. The student will be able to formulate a viable research problem, do a critical analysis of publications in the area of research, and identify a research method suitable for the work. The student will achieve the capability to write a technical paper based on his/her dissertation/ research project.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Explain research ethics, Citation, Impact factor and Plagiarism	Apply
CO2	Formulate a research problem, make a suitable research design, and identifythe data collection methods	Apply
CO3	Analyse the collected data	Analyse
CO4	Explain the role of IPR and Patent law in fostering research work, leading to creation of improved products, thus supporting economic growth and socialbenefits	Apply
CO5	Develop a technical paper for publication	Apply

iii) SYLLABUS

Introduction to Research Methodology- motivation for research, types of research, ethical issues. Identifying a research area and collecting related literature. Research problem- scope objectives, literature review, identifying research gaps, and formulate the research problem. Research design and methods, data collection and analysis . Copy right – royalty - IPR and patent law. Process of patenting and development, Procedure for grant of patents. Copy left- open access, citation, plagiarism, Impact factor. Writing a technical paper.

iv) REFERENCES

1) Stuart Melville and Wayne Goddard, *Research methodology*: *an introduction for science & engineering students.*
2) Ranjit Kumar, 2nd Edition, *Research Methodology: A Step by Step Guide for beginners.*
3) Ramappa T., *Intellectual Property Rights Under WTO*, S. Chand, 2008.
4) Robert P. Merges, Peter S. Menell, Mark A. Lemley, *Intellectual Property in New*

Technological Age, 2016.

5) Mayall, *Industrial Design*, McGraw Hill, 1992. Niebel, "Product Design", McGraw Hill, 1974.

v) COURSE PLAN

Module	Contents	Hours
I	**Introduction to Research Methodology**: Motivation towards research,Types of research. Professional ethics in research: Ethical issues, ethical committees. Identification of major conferences and important journals in a chosen area of interest. Collection of at least 10 published papers on a research problem in the chosen area.	**6**
II	**Defining and formulating the research problem:** Literature Survey, Analysing the collected papers to understand how the authors have identified the research gaps, arrived at their objectives, and formulated their research problem. Understanding how their research work is different from the previous works in the chosen area.	**6**
III	**Research design and methods:** Analyzing the collected papers to understand how the authors have formulated the research methods, both analytical methods and experimental methods. Data Collection and analysis: Analyzing the collected papers to understand the methods of data collection, data processing, analysis strategies, and tools used for analyzing the data.	**6**
IV	**Copy right:** Royalty - Intellectual property rights and patent law ‑Process of Patenting and Development, Procedure for grant of patents. Reproduction of published material: Copy left- Open access, Citation and acknowledgement. Plagiarism, Impact factor.	**6**
V	**Technical writing** : Structure and components of a typical technical paper, abstract and conclusion, illustrations and tables, bibliography, referencing and footnotes. Writing a technical paper ‑ based on the identified research problem, and using the collected papers, Literaturesurvey, Problem formulation, and Research design, and a hypothetical result.	**6**
	Total hours	**30**

LABORATORY COURSES (LBC)

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
26CE369A	Environmental Monitoring Lab I	LBC	0	0	3	2	2026

i) COURSE OBJECTIVES

The objective of this course is to enable students to familiarise themselves with various analytical techniques in Environmental Engineering for analyzing the quality of water and wastewater. The course is also designed to make students familiar with different softwares related to Environmental Engineering.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO1	Use the analytical techniques in Environmental Chemistry as well as Microbiological practices for the analysis of water and wastewater samples.	Apply
CO2	Analyse the suitability of the given water and wastewater samples for its intended purposes.	Analyse
CO3	Make use of suitable software in Environmental Engineering practices.	Apply

iii) SYLLABUS

Water quality analysis

Wastewater quality analysis

Software in Environmental Engineering practices

iv) REFERENCES

1) APHA , *Standard methods for the examination of water and waste water*, American Public Health Association, Washington DC , 23rd edition, 2017
2) *IS: 10500:2012 Drinking Water- Specification*, Second revision, Bureau of Indian Standards, 2012
3) *General Standards for Discharge of Environmental Pollutants, Part A- Effluents*, EPA 1986, CPCB
4) N. Gray, M. Calvin and S. C. Bhatia, *Instrumental Methods of Analysis*, CBS Publishers and distributors, New Delhi, 2019
5) R. C. Dubey and D. K. Maheshwari, *Practical Microbiology*, S.Chand publishers, 2010
6) F.W. Fifield and P.J. Haines, *Environmental Analytical Chemistry*, Wiley-Blackwell, 2nd edition, 2000

v) COURSE PLAN

No.	Topic	No. of lab hours
1	Analysis of water quality parameters like pH, Conductivity, Turbidity , Acidity, Alkalinity and Total solids in a given sample	3
2	Analysis of Residual Chlorine and Iron in a given water sample	3
3	Analysis of Chlorides and Sulphates in a given water sample	3
4	Analysis of Nitrate and Phosphate in a given water sample	3
5	Analysis of BOD and COD in a given water sample	4
6	Analysis of oil and grease in a given water sample	3
7	Analysis of Heavy metals (any two) in a given sample	3
8	Study of instruments and equipment in a Microbiology Lab	1
9	Culture media preparation and Pure culture techniques in Microbiology	4
10	Preparation of Gram stained smear of bacteria	3
11	Isolation of microorganisms from soil ,water & air	3
12	Determination of total bacterial population by standard plate count technique	3
13	Analysis of coliforms and *E coli* by MPN and Membrane filtration technique	5
14	Environmental Engineering software	4
	Total hours	**45**

b) SEMESTER II (M2)

PROGRAMME CORE COURSE (PCC)

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
26CE361C	Biological Wastewater Treatment	PCC	4	0	0	4	2026

i) COURSE OBJECTIVES

This course introduces the biological processes used in wastewater treatment with emphasis on microbial ecology, process kinetics, reactor modelling and design of biological treatment systems. The course equips students with analytical and design skills and introduces current practices, operational challenges and sustainability considerations in biological wastewater treatment and sludge management.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO 1	Explain microbial metabolism, growth kinetics and principles governing biological wastewater treatment processes.	Understand
CO 2	Apply Monod-based kinetic models and determine kinetic coefficients for biological treatment systems.	Apply
CO 3	Analyse the performance and design considerations of aerobic biological treatment reactors	Analyse
CO 4	Design suspended and attached growth biological treatment systems based on influent characteristics and regulatory requirements.	Apply
CO 5	Choose anaerobic treatment systems, sludge digestion and disposal options with respect to sustainability and resource recovery	Apply

iii) SYLLABUS

Fundamentals of biological wastewater treatment- objectives, enzyme kinetics, types of biological processes, Microbial metabolisms- bacterial growth patterns

Microbiological treatment kinetics and flow regimes- Michaelis -Menten and Monod models

Aerobic biological treatment- Attached growth and suspended growth treatment systems

Activated Sludge Process (ASP), Sequencing Batch Reactor (SBR), Trickling Filter (TF), Aerated lagoons, Stabilization ponds

Sludge treatment, resource recovery and disposal

iv) REFERENCES

1) Metcalf & Eddy, George Tchobanoglous, Franklin Burton and H. David Stensel, *Wastewater Engineering; Treatment and Resource Recovery*, McGraw Hill Education, 5th edition, ISBN: 978-0073401188**,** 2014

2) Grady Jr., C. P. L., G. T. Daigger, N. G. Love, and C. D. M. Filipe, *Biological Wastewater Treatment*, CRC Press, 3rd Edition, ISBN: 978-1439815126, 2011
3) Mark J. Hammer and Mark J. Hammer Jr., *Water and Wastewater Technology*, Pearson Education, 7th edition, ISBN: 978-0132571589**,** 2012
4) Arcadio P. Sincero and Gregoria A. Sincero, *Environmental Engineering: A Design Approach*, Pearson Education Services Pvt. Ltd., 2nd edition, ISBN: 978-9332586548**,** 2016
5) Soli J. Arceivala and Shyam R. Asolekar, *Wastewater Treatment for Pollution Control and Reuse*, McGraw Hill Education, 3rd edition, ISBN: 978-0074621998**.,** 2007
6) Syed R. Qasim, *Wastewater Treatment Plants- Planning, Design & Operation*, CRC Press, 2nd edition, ISBN: 978-1138073934**,** 2017
7) *Manual on Sewerage and Sewage Treatment*, CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 2013

v) COURSE PLAN

Module	Contents	No. of hours
I	**Fundamentals of biological wastewater treatment:** Objectives and role of biological treatment in wastewater management, Microbial ecology of wastewater treatment systems, Role of enzymes in biodegradation processes, Enzyme kinetics and factors affecting biological reaction rates, Types of biological processes- aerobic, anoxic, and anaerobic, Microbial metabolisms- heterotrophic and autotrophic growth, Bacterial growth patterns and phases	**12**
II	**Treatment kinetics and reactor concepts:** Microbiological treatment kinetics and flow regimes, Michaelis–Menten and Monod models, Biomass growth kinetics with soluble substrates, Yield coefficients, observed yield, endogenous decay, Oxygen requirements and temperature effects, Evaluation of kinetic constants from experimental and plant data, Numerical problems and case-based illustrations	**12**
III	**Suspended growth biological treatment systems:** Overview of suspended growth processes and reactor modeling Activated Sludge Process (ASP)- Process description and configurations, Microbiology of activated sludge, Aeration methods and oxygen transfer, Process analysis and design considerations, Design of ASP reactors and secondary clarifiers, Operational issues and trouble shooting, Process modifications (extended aeration, oxidation ditch, MBR-introduction) Sequencing Batch Reactor (SBR)- Process operation, cycle phases, design principles Moving bed biofilm reactor (MBBR)- principle, biofilm carrier media, design considerations	**13**

IV	**Attached growth and Natural treatment systems:** Attached growth processes- principles and classification, Trickling filters- Media types and filter classification, Biofilm microbiology, Design considerations and hydraulic loading, Recirculation requirements and NRC equations, High rate trickling filters and operational issues Aerated lagoons- types, performance and design considerations Waste stabilization ponds- classification, design parameters and limitations	**12**
V	**Anaerobic treatment, Sludge management and resource recovery :** Anaerobic treatment processes- fundamentals, microbiology, advantages and limitations, High- rate and hybrid anaerobic reactors Upflow Anaerobic Sludge Blanket (UASB) reactors and Expanded Granular Sludge Bed (EGSB) reactors- principle, design considerations, operation, limitation Anaerobic filters and two-stage anaerobic reactor concepts Sludge digestion- aerobic and anaerobic digestion, Sludge stabilization, disposal and resource recovery	**11**
	Total hours	**60**

INDUSTRY ELECTIVE COURSES

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
26CE366A	Industrial Effluent Management	IEC	3	0	0	3	2026

i) COURSE OBJECTIVES

This course provides in-depth knowledge of industrial wastewater generation, characterization, environmental impacts, regulatory requirements and advanced treatment technologies. Emphasis is placed on the analysis and design of sustainable industrial wastewater treatment systems integrating pollution prevention, waste minimization, resource recovery, water reuse and zero liquid discharge (ZLD) concepts. The course equips students with the ability to evaluate industry-specific effluent management strategies using techno-economic, environmental and sustainability perspectives.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Identify the sources, characteristics and effects of industrial effluents	Apply
CO2	Evaluate industrial wastewater treatment systems using a systematic approach incorporating pollution prevention and waste minimisation strategies.	Evaluate
CO3	Select appropriate treatment technologies for industrial effluents based on the effluent characteristics.	Apply
CO4	Analyse the common industrial processes and suggest suitable waste minimization methods	Analyse
CO5	Assess industry-specific effluent treatment systems for regulatory compliance, techno-economic feasibility and sustainability.	Evaluate

iii) SYLLABUS

Industrial pollution- sources, sampling, characteristics and effects

Development of industrial effluent treatment system and pollution prevention

Industrial effluent treatment technologies

Typical industrial processes and regulatory framework

Environmental standards related to prevention and control of industrial effluents

Specific industries and effluent management – Textile, Tannery, Dairy, Pulp and paper, Paper recycling- case studies

Resource recovery, circular economy approaches in industrial effluent management

iv) REFERENCES

1) Woodard and Curran, Inc., *Industrial Waste Treatment Handbook*, Butterworth-Heinemann Ltd., 2nd edition, ISBN; 978-0080459868, 2011
2) Ogbiye Adebanji , *Management of Industrial Effluents- an Engineering Approach*, LAP Lambert Academic Publishing, 2016
3) N. Manivasakam, *Industrial Effluents- Origin, Characteristics, Effects, Analysis and Treatment*, Chemical Publishing Co Inc. US, 2016
4) N.L. Nemerow, *Theories and practices of Industrial Waste Treatment*, Addison-Wesley Publishing Company, 2007
5) N.L.Nemerow, *Industrial Waste Treatment: Contemporary Practice and Vision for the future*, Butterworth-Heinemann Inc., 1st edition, 2006
6) W. Wesley Eckenfelder, *Industrial Water Pollution Control*, McGraw Hill Series (In Water Resources and Environmental Engineering), Mc-Graw Hill Education, 3rd edition, 1999
7) Freeman, H.M, *Industrial Pollution Prevention Handbook*, McGraw Hill Education, 1st edition, 2017
8) Metcalf & Eddy, *Wastewater Engineering: Treatment and Resource Recovery*, McGraw Hill, 5th edition, ISBN: 978-0073401188, 2014
9) Paul L. Bishop, *Pollution Prevention: Fundamentals and Practice*, Waveland Pr Inc., 2004
10) James G. Mann and Y.A. Liu, *Industrial Water Reuse and Wastewater Minimization*, McGraw Hill Education,1999
11) The Environment (Protection) Rules, 1986 – Schedule I: Standards for Emission or Discharge of Environmental Pollutants from various Industries

v) COURSE PLAN

Module	Contents	Hours
I	**Industrial pollution – sources, sampling, characteristics and effects** Types of industries and industrial pollution, Sources and characteristics of industrial wastes, Population equivalent concept Effects of industrial effluents on receiving water bodies, sewer systems, land, sewage treatment plants and human health Industrial wastewater sampling – grab and composite sampling, frequency, sampling locations, preservation, statistical handling of data Objectives of industrial pollution assessment studies	9
II	**Development of industrial effluent treatment system and pollution prevention:** Approach for development of industrial effluent treatment system (11 step methodology) with suitable examples	9

	Analysis of manufacturing process, pollution prevention program, wastewater characterization study, second level waste minimization program, selection of candidate technologies, bench scale investigations, pilot scale investigations, preliminary designs, economic comparisons, final design Waste volume reduction - Classification of wastes. immaculate housekeeping, substitution of materials, conservation of wastewater, production changes - recycle and reuse of effluents Waste strength reduction - changing manufacturing processes/equipment, segregation of waste streams, flow equalization, proportioning of waste, pH control/neutralisation, by-product recovery, waste exchange	
III	**Effluent treatment methods:** Removal of suspended and colloidal solids Removal of organic and inorganic pollutants Removal of heavy metals, oil, grease, biodegradable organics, toxic organics, cyanide, fluoride Sludge handling ,disposal and valorization Combined treatment of industrial and municipal effluents	**9**
IV	**Typical industrial processes and Regulatory framework:** Industrial processes and wastewater generation: descaling, degreasing, rinsing, surface treatment, electroplating, anodizing, deinking Wastewater characteristics from food, meat processing, tannery, pulp and paper, chemical and textile industries Environmental standards and discharge regulations, CPCB/SPCB regulatory framework, consent mechanisms and compliance monitoring, Industrial wastewater reuse standards and environmental auditing	**9**
V	**Specific industries and effluent management:** Sources and characteristics of specific industrial effluents Wastewater treatment flow sheets and waste minimization strategies for selected industries - Textile, Tannery, Dairy, Pulp and Paper, Paper recycling-Case studies Zero Liquid Discharge (ZLD)- concepts, design approach, advantages and limitations Resource recovery and circular economy approaches in industrial effluent management	**9**
	Total hours	**45**

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
26CE366B	Circular Economy for Sustainable Resource Management	IEC	3	0	0	3	2026

i) COURSE OBJECTIVES

This course introduces the principles, strategies and practices of a circular economy including theoretical frameworks, case studies and technological innovations that drive the transition from linear to circular economies. Students will explore how circular economy models can be integrated into existing systems to promote sustainability, reduce waste and optimize resource efficiency. The course also focuses on industrial applications, legal frameworks, and the socio-economic implications of circularity.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Explain the key concepts, principles and methodologies associated with circular economy and sustainable development	Understand
CO2	Identify the role of circular economy in waste management, material recovery and industrial applications	Apply
CO3	Apply circular economy principles to develop sustainable business models, product designs and industrial symbiosis strategies	Apply
CO4	Explain the global and national policies and legal frameworks relevant to circular Economy	Understand

iii) SYLLABUS

Introduction to Circular Economy, Circular Sustainability, SDGs

Characteristics of Circular Economy

Circular design, Towards Zero Waste Management, Innovation and Assessment

Case Studies and real-world applications, Legal and Policy Framework

iv) REFERENCES

1) Walter R. Stahel, *The Circular Economy A User's Guide*, Routledge, 1st edition, ISBN: 978-0367330620, 2019

2) Peter Lacy, Jessica Long, Wesley Spindler, *The Circular Economy Handbook: Realizing the Circular Advantage*, Palgrave Macmillan, 1st edition, 2020

3) Shalini Goyal Bhalla, Circular Economy: (Re) Emerging Movement, Invincible Publisher, 2020

4) Peter Lacy, Jakob Rutqvist, *Waste to Wealth: The Circular Economy Advantage*, Palgrave Macmillan, 1st edition, 2015

5) Franco-García, María-Laura, Jorge Carlos Carpio-Aguilar, and Hans Bressers, *Towards Zero Waste: Circular Economy Boost*, *Waste to Resources,* Springer International, 2019

6) Marcello Tonelli, Nicolò Cristoni, *Strategic Management and the Circular Economy*, Taylor & Francis, 1st edition, 2018

7) Sadhan Kumar Ghosh, *Circular Economy: Global Perspective*, Springer, 1st edition, ISBN: 978-9811510519, 2020

8) Ken Webster, *Circular Economy: A Wealth of Flows*, Zaccheus Entertainment, 2nd edition, ISBN: 978-0992778460, 2017

V) COURSE PLAN

Module	Contents	Hour
I	**Introduction to Circular Economy:** Linear Economy and its emergence, Economic and Ecological disadvantages of linear economy, Replacing Linear economy by Circular Economy, Concept of Circular Economy, A differential - Linear vs Circular Economy, Circular Sustainability, Role of Circular Economy in Sustainable Development Goals (SDGs), Barriers and Drivers for implementing Circular Economy practices.	**8**
II	**Characteristics of Circular Economy:** Material recovery and waste reduction- Material Collection Facility (MCF) and Resource Recovery Facility (RRF), Reducing negative externalities, Circular loops and the Butterfly diagram, Social and economic dimensions of Circular Economy, Circular Economy metrics and Key Performance Indicators (KPIs).	**9**
III	**Circular design, innovation and Assessment:** Cradle to Cradle design, Sustainable Product design and manufacturing, Industrial Symbiosis, Zero waste: Waste Management and Resource recovery, Circular design, Research and innovation, Life Cycle Assessment, Circular Business Models.	**9**
IV	**Case Studies:** Business models to Circular Economy, Solid Waste Management and Wastewater Treatment, Plastics and Circular Economy, Extended Producer Responsibility (EPR), Polluters Pays Principle (PPP), Industrial symbiosis, Eco-parks, Circularity in urban planning and Smart cities.	**10**
V	**Legal and policy framework:** Role of governments and networks, Sharing best practices, Universal circular economy policy goals, India and CE strategy, ESG	**9**
	Total hours	**45**

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
26CE366C	Environmental Nanotechnology	IEC	3	0	0	3	2026

i) COURSE OBJECTIVES

The aim of this course is to provide a comprehensive understanding of the fundamentals of nanotechnology, including the unique properties and behaviors of nanomaterials. The course details the types of nanomaterials and their applications in environmental monitoring and remediation.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Explain the principles of nanotechnology and how they can be applied to environmental challenges.	Understand
CO2	Identify the techniques for synthesis of nanomaterials with specific properties suitable for environmental applications.	Apply
CO3	Identify the methods to characterize nanomaterials ensuring their safety and effectiveness in the environmental context.	Apply
CO4	Analyse the behaviour of nanomaterials in environmental systems, including their movement, transformation and potential impacts.	Analyse
CO5	Apply the principles of nanotechnology for purifying air and water, addressing pollution and improving environmental quality.	Apply

iii) SYLLABUS

Nano synthesis, Nano biocomposites

Nanoremediation and Nanofiltration- Environmental nano remediation technology- Nanotechnology for water remediation and purification

Treatment of industrial waste- Application of industrial ecology to nanotechnology- Environmental life cycle of nano materials

Eco toxicology- Exposure to nanoparticles- biological damage

Nanomaterials in future

iv) REFERENCES

1) Mao Hong Fan, Chin-Pao Huang, Alan E Bland, Z Honglin Wang, RachidSliman, Ian Wright. *Enviro-nanotechnology*, Elsevier, 2010

2) Jo Anne Shatkin*, Nanotechnology: Health and Environmental risk,* CRC press, 1st edition, 2008

3) M.H. Fulekar, *Nanotechnology: Importance and Applications,* Dreamtech Press, 2019

4) M. Steinfeldt, Avon Gleich, U. Petschow, R. Haum, *Nanotechnologies, Hazards and Resource efficiency,* Springer, 2007.

5) Gary Wiederrcht, *Handbook of Nanofabrication*, Elsevier, 1st edition, 2009

v) COURSE PLAN

Module	Contents	Hours
I	**Nanosynthesis:** Synthesis of nanomaterials by physico- chemical approaches, Bionanocomposites- Nanoparticles and microorganisms- microbial synthesis of Nanomaterials- Biological methods for synthesis of nano emulsions using bacteria- Fungi and actinomycetes	9
II	**Nano biocomposites:** Plants based nanoparticle synthesis- Nanocomposite biomaterials- Fibres, devises and Structures- Nano Bio Systems Nanoremediation- Identification and characterization of Hazardous waste- Nano pollution- air- Water- Soil Contaminants-Identification and Characterization Organic and Inorganics-Environmental cleanup technologies.	9
III	**Nanoremediation and Nano filtration:** Nanomaterials-Remediation-Nanomembranes- Nanomeshes-Nanofibres-Nanoclays and Adsorbents- Zeolites- Nano catalysts -Bio Polymers-Single enzyme nano particles- Bio metallic iron nanoparticles- Nano photo catalysis. Environmental nano remediation technology- thermal- Physico-Chemical and biological methods Nano filtration for treatment of waste-Removal of organics & inorganics and Pathogens- nanotechnology for water remediation and purification	9
IV	**Treatment of industrial wastes:** Treatment of hi-tech industrial waste waters using nanoparticles/ modified structures/ devices. Environmental benefits of nanomaterials	9

	Application of industrial ecology to nanotechnology Fate of Nano materials in environment- Environmental life cycle of nano materials- Environmental and health impacts of nanomaterials- toxicological threats	
V	**Eco-toxicology:** Exposure to nanoparticles- Biological damage- Threat posed by nano materials to humans- Environmental reconnaissance and surveillance. Corporate social responsibility for nano technology Nanomaterials in future- Implications	**9**
	Total hours	**45**

LABORATORY COURSES (LBC)

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
26CE369B	Environmental Monitoring Lab II	LBC	0	0	3	2	2026

i) COURSE OBJECTIVES

The objective of this course is to enable students to familiarize themselves with various analytical techniques in Environmental Engineering. The course is also designed to make students familiar with different Modelling techniques related to Environmental Engineering.

ii) COURSE OUTCOMES

After the completion of the course the student will be able to:

CO 1	Analyse the given soil and sediment samples using the various analytical techniques in Environmental Chemistry.	Analyse
CO 2	Identify the various techniques for air quality and noise pollution analysis.	Apply
CO 3	Make use of suitable modelling techniques in Environmental Engineering practices.	Apply

iii) SYLLABUS

Soil and Sediment analysis
Air quality analysis
Noise pollution analysis
Introduction to Modelling techniques

iv) REFERENCES

1) APHA, *Standard methods for the examination of water and wastewater*, American Public Health Association, Washington DC, 23rd edition, 2017
2) *IS: 10500:2012 Drinking Water- Specification*, Second revision, Bureau of Indian Standards, 2012
3) *General Standards for Discharge of Environmental Pollutants, Part A-Effluents*, EPA 1986, CPCB
4) F.W. Fifield and P.J. Haines, *Environmental Analytical Chemistry,* Wiley-Blackwell, 2nd edition, 2000
5) N.Gray, M.Calvin and S.C.Bhatia, *Instrumental Methods of Analysis*, CBS Publishers and distributors, New Delhi, 2019
6) *The Noise Pollution (Regulation & Control) Rules*, 2000, S.O 123 (E), (Amendment 2010), Ministry of Environment and Forests, Government of India.
7) *National Ambient Air Quality Standards*, CPCB, Government of India

v) COURSE PLAN

No.	Topic	No. of lab hours
1	Analysis of Organic Carbon in soil	3
2	Analysis of Nitrates in soil	3
3	Analysis of Sulphates in soil	3
4	Analysis of soil pH & Chloride content	3
5	Analysis of sediments - pH ,ORP	3
6	Analysis of sediments - heavy metals	3
7	Analysis of Calcium in a given water sample	2
8	Analysis of Potassium in a given water sample	2
9	Analysis of Sodium in a given water sample	2
10	Analysis of Lithium in a given water sample	2
11	Analysis of Noise pollution	3
12	Analysis of air quality parameters - PM 2.5 & PM 10	3
13	Modelling techniques-Air quality & water Quality	3
14	Modelling techniques- Climate change & Life Cycle Analysis	5
15	Modelling techniques- Water Supply & Sewer design	5
	Total hours	**45**

3. ASSESSMENT PATTERN

a) Program Core Courses /Program Core Course with Practical Component

A PCC/PCCP will be evaluated out of 100 marks; 50 marks for Continuous internal assessment (CIA) and 50 marks for End semester evaluation (ESE).

Evaluation shall include application, analysis, and design based questions for both CIA and ESE.

Continuous Internal Assessment (CIA): 50 marks

Micro project/ Laboratory/Course based project:	30 marks
Course based task/ Seminar/Quiz:	10 marks
Continuous Assessment Test (CAT), 1 No:	10 marks
(CAT shall include minimum 60% of the syllabus)	

Micro project/ Course based project shall be done individually. Group projects are not permitted.

End Semester Examination (ESE): 50 marks

End semester examination (ESE) will be conducted by the Controller of Examinations (CoE). Duration of the examination shall be 180 minutes.

The question paper will contain 7 questions with minimum one question from each module, having 10 marks for each question. A question can have sub parts. Students shall answer any five questions.

The questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, overall achievement and maturity of the students in a course, through questions relating to theoretical/ practical knowledge, derivations, problem solving and quantitative evaluation.

b) Program Elective Course/Program Elective Course with Practical Component

A Program Elective Course conducted as a theory course along with its related laboratory experiments comes under the course type PECP. A PEC/PECP is evaluated out of 100 marks; 50 marks for CIA and 50 marks for ESE.

Evaluation shall include application, analysis, and design based questions for both CIA and ESE.

Continuous Internal Evaluation: 50 marks

Preparing a review article based on peer reviewed Original publications (Minimum 10 publications shall be referred) /Micro project/Laboratory:	30 marks
Course based task/ Seminar/ Data collection and interpretation:	10 marks
Continuous Assessment Test (CAT), 1 No:	10 marks

(CAT shall include minimum 60% of the syllabus)

End Semester Examination: 50 marks

The ESE will be conducted by the CoE. Duration of the examination shall be 180 minutes. The question paper will contain 7 questions with minimum one question from each module, having 10 marks for each question. A question can have two or more sub parts. Students shall answer any five questions.

The questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, testing of overall achievement and maturity of the students in a course, through questions relating to theoretical/ practical knowledge, derivations, problem solving and quantitative evaluation.

c) Audit Course (Research Methodology and IPR)

An audit course is evaluated out of 100 marks; 50 marks for CIA and 50 marks for ESE.

Continuous Internal Evaluation: 50 marks

Course based task:	20 marks
Seminar/Quiz:	20 marks
Continuous assessment Test (CAT), 1 No:	10 marks

(CAT shall include minimum 60% of the syllabus)

End Semester Examination: 50 marks

The ESE will be conducted by the CoE. Duration of the examination shall be 180 minutes.

The question paper will contain 7 questions with minimum one question from each module, having 10 marks for each question. Students shall answer any five questions.

d) Internship

Internships are educational and career development opportunities, providing practical experience in a field or discipline. They are structured, short-term, supervised placements often focused around particular tasks or projects with defined timescales. A student has the opportunity to do internship for one semester either in M3 or in M4. Such students will carry out a Project work in the other semester.

A student shall carry out the Internship at an Industry/ Research Organization or at another institute of higher learning and repute (Academia). The students must select the organization for doing Internship on their own, with prior approval from the respective PG Programme Coordinator. Every student shall be assigned a Faculty Supervisor at the beginning of his/her Internship. The training shall be related to their specialization. The internship must be carried out for duration of four to five months during the third semester or fourth semester. On completion of the Internship course, the student is expected to be able to develop skills in facing and solving the problems experiencing in the related field.

Types of Internships

- Industry Internship with/ without Stipend
- Government / PSU Internship (BARC/ Railway/ ISRO etc.)
- Internship with prominent education/ Research Institutes
- Internship with Incubation centers/ Start-ups

Guidelines

- The duration of internship must be for a minimum of four months and a maximum of five months.
- Students can take mini projects, assignments, case studies by discussing it with concerned authority from industry and can work on it during internship.
- All students should compulsorily follow the rules and regulations of the industry.
- Every student should take prior permissions from concerned industrial authority if they want to use any drawings, photographs or any other document from the industry.
- Student should follow all ethical practices and Standard operating procedure (SOP) of the industry.
- Students must take necessary health and safety precautions as laid by the industry.
- Student should contact his /her Guide/Supervisor from the College on a weekly basis to communicate the progress.
- Each student has to maintain a diary/log book
- After completion of internship, students are required to submit
    - ✓ Report of work done
    - ✓ Copy of Internship certificate

- ✓ Feedback from internship mentor in the place of Internship
- ✓ Proof of Stipend (in case of paid internship).

Evaluation of Internship

Internship will be evaluated out of 100 marks for CIA.

Student's diary/ Daily Log: 25 Marks

Evaluation done by the Industry: 25 Marks

Internship Report: 25 Marks

Comprehensive Viva Voce: 25 Marks

Student's Diary/ Daily Log

The main purpose of writing daily diary is to cultivate the habit of documenting and to encourage the students to search for details. It develops the students' thought process and reasoning abilities. The students should record in the daily training diary the day to day account of the observations, impressions, information gathered and suggestions given, if any. It should contain the sketches & drawings related to the observations made by the students. Student's diary must be signed each day by the supervisor/ in charge of the section where the student has been working.

Format of Student's Diary

Name of the Organization/Section:

Name and Address of the Section Head:

Name and Address of the Supervisor:

Name and address of the student:

Internship Duration: From ..... To .....

Brief description about the nature of internship:

Day	Brief write up about the Activities carried out: Such as design, sketches, result observed, issues identified, data recorded, etc.
1	
2	
3	

Signature of Industry supervisor Signature of Head/ HR Manager

Office Seal

Format of Attendance Sheet

Name of the Organization/ Section:

Name and Address of the Section Head:

Name and Address of the Supervisor:

Name and address of the student:

Internship Duration: From .... To ....

Month & Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
Month & Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
Month & Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	

Signature of Industry supervisor Signature of Head/ HR Manager

Office Seal

Note:

- Student's Diary shall be submitted by the students along with attendance record and an evaluation sheet duly signed and stamped by the industry to the Institute immediately after the completion of the training.
- Attendance Sheet should remain affixed in daily training diary. Do not remove or tear it off.
- Student shall sign in the attendance column. Do not mark 'P'.
- Holidays should be marked in red ink in the attendance column. Absence should be marked as 'A' in red ink.

Student's diary will be evaluated on the basis of the following criteria:

- Regularity in maintenance of the diary
- Adequacy and quality of information recorded
- Drawings, design, sketches and data recorded
- Thought process and recording techniques used
- Organization of the information.

Format for Evaluation of Intern by the Industry

Student Name : Date:
Supervisor Name : Designation:
Company/ Organization :
Internship Address:
Dates of Internship: From_____ To_____

Please evaluate intern by indicating the frequency with which you observed the following parameters:

Parameters/ Marks	Needs improvement (0 -0.25 marks)	Satisfactory (0.25- 0.5 marks)	Good (0.75 marks)	Excellent (1 mark)
Behavior				
Performs in a dependable manner				
Cooperates with coworkers and supervisor				
Shows interest in work				
Learns quickly				
Shows initiative				
Produces high quality work				
Accepts responsibility				
Accepts criticism				
Demonstrates organizational skills				
Uses technical knowledge and expertise				
Shows good judgment				
Demonstrates creativity/ originality				
Analyzes problems effectively				

Is self-reliant				
Communicates well				
Writes effectively				
Has a professional attitude				
Gives professional appearance				
Is punctual				
Uses time effectively				

Overall performance of student Intern (Tick one):

Needs improvement (0.50 mark)
Satisfactory (1.0 mark)
Good (1.5 mark)
Excellent (2.0 mark)

Additional comments, if any (2 marks) :

Signature of Industry Supervisor *Signature of Section Head/HR Manager*

Office Seal

Internship Report:

After completion of the internship, the student should prepare a comprehensive report to indicate what he has observed and learnt in the training period and should be submitted to the faculty Supervisor. The student should prepare the final report on the assigned topics. Diary/ daily log will also help to a great extent in writing the report since much of the information has already been incorporated by the student into the diary. The training report should be signed by the Internship supervisor, PG Programme Coordinator and Faculty mentor.

The Internship report will be evaluated on the basis of following criteria:

- Originality
- Adequacy and purposeful write-up
- Organization, format, drawings, sketches, style, language etc.
- Variety and relevance of learning experience
- Practical applications, relationships with basic theory and concepts taught in the course.

Comprehensive Viva Voce:

Viva Voce will be done by a committee comprising Faculty Supervisor, PG Programme Coordinator, and one faculty member from a sister department. This committee shall evaluate the internship report also.

e) Laboratory Courses

The laboratory courses will have only Continuous Internal Assessment and carries 100 marks. Final assessment shall be done by two examiners; one examiner will be a senior faculty from the same department.

Continuous internal assessment: 100 marks

Performance in regular laboratory experiments:	70 Marks
Final assessment/ laboratory test:	30 marks

f) Industry Elective Course

Engineering students frequently aspire to work in areas and domains that are key topics in the industry. There are concerns by recruiters that skill sets of engineering students do not match with the Industry requirements, especially in the field of latest topics.

Industry knowledge aids in the bridge building process between academic institutions and industry. It also aids students in expanding their knowledge and innovating by allowing them to create something new. Core engineering courses provide students with a strong foundation. Evolving technology necessitates new methods and approaches to progress, prosperity, and the inculcation of problem-solving techniques. Industry knowledge will enable the students to deal with any scenario more effectively, thus fulfilling the current industry demands.

Rapid technological advancements have resulted in a massive revival in the way engineering works in the industry. Projects necessitate the integration of knowledge and abilities from a diverse variety of engineering specialties, with the barriers between them becoming increasingly blurred.

Students can choose courses offered by Industries that cover a wide range of highly relevant topics such as artificial intelligence, internet of things, big data, automation, and other relatable courses.

IEC will be evaluated out of 100 marks; 50 marks for CIA and 50 marks for ESE.

Continuous Internal Assessment: 50 marks

The continuous internal evaluation will be done by the expert in the Industry handling the course, and the coordinator from the college.

Micro project/ Course based project: 30 marks

Course based task/Seminar/Quiz: 10 marks

Continuous assessment Test (CAT), 1 No: 10 marks

(CAT shall include minimum 60% of the syllabus)

End Semester Examination: 50 marks

The ESE will be conducted by the CoE using the question paper provided by the industry. Total duration of the examination shall be 180 minutes.

The question paper will contain 7 questions with minimum one question from each module, having 10 marks for each question. Students shall answer any five questions. Evaluation of the answer scripts will be done by the expert in the Industry handling the course or the coordinator from the college under the expert's guidance.

g) Skill/Ability Enhancement Course

SAEC are online MOOC of 12 weeks duration and shall be considered only if it is conducted by the agencies namely AICTE/ NPTEL/ SWAYAM/ NITTTR. The course should have a proctored/ offline end semester examination. Students can do the SAEC credited in M2 according to their convenience from their first semester, but shall complete it by their second semester. Students can do the SAEC credited in M3 according to their convenience from their first semester, but shall complete it by their third semester. The list of MOOC must be those approved by the concerned Board of studies, from which the students can choose their courses. A course may be approved only if at least 70% of the course content matches with the area/ stream of study. The course shall not be considered if its content has more than 50% of overlap with a core/ elective course in the concerned discipline or with an open elective.

A credit of 3 and a grade point of 10 will be awarded to all students whoever successfully completes the SAEC credited in M3. Marks/ GPA awarded to the other SAEC shall be used for SGPA/CGPA computation.

h) Mini Project

Mini project can help to strengthen the understanding of the fundamentals through application of theoretical concepts, and to boost their skills and widen the horizon of thinking. The ultimate aim of an engineering student is to resolve a problem by applying theoretical knowledge. Doing more projects enhances problem solving skills. The Mini project ensures preparedness of students to undertake project work in M3 and M4.

Students should identify a topic of interest in consultation with his/her PG Programme Coordinator. They should demonstrate the novelty of the project through the results and outputs. This mini project work is assessed in three evaluations, two interim evaluations and a final evaluation. The evaluations will be done by a committee comprising of Project Coordinator, Two senior faculty members in the department and the student's Project Supervisor.

Final evaluation will be conducted only if the Interim project report approved by the student's supervisor is submitted. The Plagiarism level in the report should be ≤ 25%, assessed based on the overall similarity index given by Turnitin licensed to the College.

Mini Project will be evaluated out of 100 marks under CIA, and no ESE.

1) First evaluation:

Evaluation committee: 20 marks

Literature Survey:	7 marks
Objectives and Methodology:	7 marks
Clarity of presentation:	6 marks

2) Second evaluation:

Evaluation committee: 20 marks

Design:	7 marks
Implementation plan:	5 marks
Expected results:	8 marks

3) Final evaluation: 60 marks

a) Supervisor/ Guide: 10 marks

Log book and Regularity:	5 marks
Overall evaluation of the project work:	5 marks

b) Evaluation committee: 50 marks

Demonstration of functionality/ specifications:	20 marks
Level of completion:	5 marks
Clarity of presentation:	5 marks
Knowledge on the project work:	5 marks
Interim project report:	
Technical content:	5 marks
Adequacy of references:	5 marks
Templates followed:	5 marks

i) Project

The students must carry out the project work either in the college or in any CSIR/ industrial R&D organization/ any other reputed Institute which have facilities for project work in the proposed area.

Project work outside the College:

For doing project work outside the college, the following conditions are to be met:

- They have completed successfully the course work prescribed in the approved curriculum up to the second semester.
- The student has to get prior approval from the DLAC.
- Students availing this facility should continue as regular students of the College.
- Facilities required for doing the project work shall be available in the Organization/ Industry. A certificate stating the time period for which the facilities shall be made available to the student, issued by a competent authority from the Organization/ Industry shall be submitted by the student along with the application.
- The student should have an external as well as an internal supervisor. The internal supervisor shall belong to the college and the external supervisor shall be a Scientist or Engineer from the Institution/ Industry/ R&D organization with which the student proposes to do the project work. The external supervisor shall be with a minimum Post graduate degree in the related area.
- The MOOC must be completed as per the curriculum requirements.
- The student has to furnish his/her monthly progress as well as attendance report signed by the external supervisor and submit the same to the concerned Internal supervisor.
- The external supervisor is to be preferably present during all stages of evaluation of the project.

Internship leading to Project`:

Students who complete their internship in M3 at some reputed organization are allowed to continue their work as project in their fourth semester, after getting approval from the DLAC. Such students shall make a brief presentation regarding the work they propose to carry out before the DLAC for a detailed scrutiny and to resolve its suitability for accepting it as an M.Tech project. Once accepted, they will be permitted to complete their project in that organization (where they have successfully completed their internship) during their fourth semester.

Project as part of Employment:

Students may be permitted to discontinue the programme and take up a job, provided they have successfully completed all the courses till the second semester (FE status students are not permitted) prescribed in the approved curriculum. The project work can

be done during a later period either in the organization where they work if it has R & D facility, or in the College. Such students should submit application with details (copy of employment offer and the plan of completion of their project) to the Dean (PGSR) through the HoD. When the student plans to do the project work in the organization with R & D facility where they are employed, they shall submit a separate application with the following details:

- Name of R&D Organization/Industry
- Name and designation of an external supervisor from the proposed organization/industry (a scientist or engineer with a minimum post graduate degree in the related area), along with his profile and consent letter.
- Name and designation of a faculty member of the College as internal supervisor, and his/her consent letter.
- Letter from the competent authority from the Organization/ Industry granting permission to do the project work.
- Details of the proposed work along with the work plan for completion of the project.

DLAC will scrutinize the proposal and forward to CLAC for approval.

When a student does his project work along with the job in the organization (with R & D facility) where they are employed, the project work shall be completed in four semesters (two semesters of dissertation work along with the job may be considered as equivalent to one semester of dissertation work at the college). He should complete the M. Tech programme within four years from the date of admission as per the regulation. Extensions may be granted based on the requests from the student and recommendation of the supervisors. Method of assessment of the project will be the same as in the case of regular students.

Evaluation of Project (Phase I) in M3

Project (Phase I) will be evaluated out of 100 marks under CIA, and has no ESE. There will be two evaluations (first evaluation and final evaluation). The assessment shall be done by the student's Project Supervisor, and a committee comprising of Project Coordinator, two senior faculty members in the department, and the student's Project Supervisor. Project Coordinator shall enter the marks in the CoE portal.

Final evaluation will be conducted only if the student has submitted the Interim project report approved by the Supervisor, and Plagiarism level in the Interim project report is ≤25%.

1) First evaluation: 30 marks

Project Supervisor: 10 marks

i) Progress of work: 5 marks

(Literature Survey, Objectives, Methodology)

ii) Log book and Regularity: 5 marks

Evaluation committee: 20 marks

i) Topic, Objectives: 5 marks

ii) Methodology and Implementation Plan for the work in M3: 10 marks

iii) Clarity in presentation : 5 marks

2) Final evaluation : 70 marks

Project Supervisor: 25 marks

i) Progress of work: 15 marks

ii) Log book and Regularity: 5 marks

iii) Interim Project report: 5 marks

Evaluation committee: 45 marks

i) Demonstration of work completed: 15 marks

ii) Presentation and Viva voce: 10 marks

iii) Implementation plan of work in M4 : 5 marks

iv) Interim project report: 15 marks

Technical content: 10 marks

Adequacy of references and templates followed: 5 marks

Evaluation of Project (Phase II) in M4/ Project in M3 or M4

The evaluation of Project (Phase II) has CIA for 100 marks, and ESE for 100 marks. The continuous internal assessment is done under two evaluations (first evaluation and final evaluation), by the student's Project Supervisor, and a committee comprising of Project Coordinator, two senior faculty members in the department, and the student's Project Supervisor. Project Coordinator shall enter the marks in the CoE portal.

Final evaluation will be conducted only if the student has submitted the project report approved by the Supervisor, and Plagiarism level in the project report is ≤25%.

Continuous internal assessment: 100 marks

1) **First evaluation: 40 marks**

Project Supervisor: 15 marks

i) Progress of work: 10 marks

(Experimentation and results)

ii) Log book and Regularity: 5 marks

Evaluation committee: 25 marks

i) Demonstration of work completed: 15 marks

ii) Presentation and viva : 10 marks

2) **Final evaluation : 60 marks**

Project Supervisor: 15 marks

i) Progress of work: 10 marks
(Quality and quantum of work)

ii) Project report: 5 marks

Evaluation committee: 45 marks

i) Demonstration of work completed: 10 marks

ii) Presentation and Viva voce: 10 marks

iii) Project report: 10 marks

Technical content: 5 marks

Adequacy of references: 5 marks

iv) Paper publication : 15 marks
(Published /accepted for publication in a journal/conference)

End semester examination (Viva-voce examination): 100 marks

The ESE will be done by a committee that comprises of the Project Coordinator, an external expert (from industry or research/academic institute) and the student's Project Supervisor.

Each department must submit a panel of external experts to Dean (PGSR), as per the academic calendar. The minimum qualification requirement for an external examiner is M.Tech. The number of experts to be submitted is one more than number of students divided by 6 (rounded to the next integer). Honorarium for the external expert will be as fixed by the College.

The Project coordinator will enter the ESE marks in the portal.

Marks Distribution for Viva-voce examination

i. Innovation & originality: 15 marks
   (Introduction, Recent and related literature, Scope of the work, Objectives)
ii. Implementation and execution: 20 marks
   (Methodology and work plan, Results and discussions, Quality of work done)
iii. Project Documentation: 20 marks
   (Introduction, Problem Statement, Literature review, Methodology, Results and discussions, Conclusions, Future work, References)
iv. Presentation and Defense: 40 marks
   (Clarity and effectiveness of presentation, Ability to explain the project objectives, Methodology and Findings, Handling questions and providing satisfactory answers)
v. Publication: 5 marks
   (Published/accepted for publication in a journal/conference)