DEPARTMENT OF CIVIL ENGINEERING

M.TECH
in
ENVIRONMENTAL SCIENCE AND ENGINEERING

M. TECH DEGREE PROGRAMME

in

ENVIRONMENTAL SCIENCE AND ENGINEERING

CURRICULUM & SYLLABI

Items	Board of Studies (BoS)	Academic Council (AC)
Date of Approval	12/08/2024	30/08/2024

Head of the Department

Chairman, Board of Studies

Principal

Chairman, Academic Council

CURRICULUM & SYLLABI

FOR

M. TECH DEGREE PROGRAMME

IN

ENVIRONMENTAL SCIENCE AND ENGINEERING

2022 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.

DEPARTMENT OF CIVIL ENGINEERING

M.Tech. Programme in

Environmental Science and Engineering

For the students admitted from 2024-2025

Scheduling of Courses

i) Knowledge Segments and Credits

Every course of M.Tech Programme is placed in one of the nine course types as listed in Table 1. No semester shall have more than six lecture-based courses and two laboratory courses, and/or project courses in the curriculum.

Table 1: Credit Distribution and Knowledge Domains

Sl. No.	Category	Course Type	Number of Courses	Total Credits
1	Discipline Core Course	DCC	2	6
2	Program Core Course	PCC	3	9
3	Laboratory Course	LBC	2	2
4	Program Elective Course	PEC	4	12
5	Mandatory Credit Course (Research Methodology & IPR)	RM	1	2
6	Industry/ Interdisciplinary Elective	IEC	1	3
7	Internship	PR	1	3
8	Mini Project		1	2
9	Project		2	27
10	MOOC	MOOC	1	2
11	Audit Course	AC	1	-
Total Mandatory Credits				**68**

ii) Semester-wise Credit Distribution

Semester	I	II	III	IV	Total Credits
Credits for Courses	18	18	16	16	**68**

Semester I							
Slot	**Course Type**	**Course Number**	**Course Name**	**L**	**T**	**P**	**Credit**
A	DCC	24MA060F	Probability and Statistics	3	0	0	3
B	PCC	24CE361A	Environmental Chemistry and Microbiology	3	0	0	3
C	PCC	24CE361B	Physico-Chemical Water and Wastewater Treatment	3	0	0	3
D	PEC	24CE362X	Program Elective 1	3	0	0	3
E	PEC	24CE362X	Program Elective 2	3	0	0	3
S	RM	22MC061A	Research Methodology & IPR	2	0	0	2
T	LBC	24CE369A	Environmental Monitoring Laboratory I	0	0	2	1
Total				**17**	**0**	**2**	**18**

Semester II							
Slot	**Course Type**	**Course Number**	**Course Name**	**L**	**T**	**P**	**Credit**
A	DCC	24CE360A	Solid and Hazardous Waste Management	3	0	0	3
B	PCC	24CE361C	Biological Wastewater Treatment	3	0	0	3
C	PEC	24CE362X	Program Elective 3	3	0	0	3
D	PEC	24CE362X	Program Elective 4	3	0	0	3
E	IEC	24CE36XX	Industry based/ Interdisciplinary Elective	3	0	0	3
S	PR	24CE367A	Mini project	0	0	4	2
T	LBC	24CE369B	Environmental Monitoring Laboratory II	0	0	2	1
Total				**15**	**0**	**6**	**18**

Semester III							
Slot	**Course Type**	**Course Number**	**Course Name**	**L**	**T**	**P**	**Credit**
A	MOOC	-	MOOC	-	-	-	2
B	AC	2XAC071X	Audit Course	3	0	0	-
C	PR	24CE377A	Internship	-	-	-	3
D	PR	24CE378A	Dissertation Phase I / Research Project Phase I	0	0	17	11
Total				**3**	**0**	**17**	**16**

Semester IV							
Slot	**Course Type**	**Course Number**	**Course Name**	**L**	**T**	**P**	**Credit**
D	PR	24CE378B	Dissertation Phase II / Research Project Phase II	0	0	24	16
Total				**0**	**0**	**24**	**16**

LIST OF PROGRAM ELECTIVE COURSES

Category Code	Course Number	Course Name	L	T	P	Credit
PEC	24CE362A	Environmental Impact Assessment and Management	3	0	0	3
	24CE362B	GIS and Remote Sensing for Environmental Applications	3	0	0	3
	24CE362C	Instrumental and Analytical Techniques in Environmental Engineering	3	0	0	3
	24CE362D	Geo-Environmental Engineering and Technology	3	0	0	3
	24CE362E	Environmental Health, Hygiene and Safety	3	0	0	3
	24CE362F	Mitigation and Adaptation Strategies in Climate Change	3	0	0	3
	24CE362G	Environmental System Modelling	3	0	0	3
	24CE362H	Ecological Engineering	3	0	0	3
	24CE362I	Air Pollution and Control Technologies	3	0	0	3
	24CE362J	Advanced Wastewater Treatment Technologies	3	0	0	3
	24CE362K	Environmental Biotechnology and Bioremediation	3	0	0	3
	24CE362L	Environmental Hydrology	3	0	0	3
	24CE362M	Contaminant Transportation and Remediation	3	0	0	3
	24CE362N	Environmental Toxicology	3	0	0	3
	24CE362O	Applications of AI and ML in Environmental Engineering	3	0	0	3

INTERDISCIPLINARY ELECTIVE COURSE

Slot	Category Code	Course Number	Course Name	L	T	P	Credit
E	**IEC**	24CE365A	Sustainable Technologies and Cleaner Production	3	0	0	3

LIST OF INDUSTRY-BASED ELECTIVE COURSES

Slot	Category Code	Course Number	Course Name	L	T	P	Credit
E	**IEC**	24CE366A	Industrial Effluent Management	3	0	0	3
		24CE366B	Circular Economy	3	0	0	3
		24CE366C	Environmental Nanotechnology	3	0	0	3

DETAILED SYLLABI (M1)

M.TECH. ENVIRONMENTAL SCIENCE AND ENGINEERING

SEMESTER I

DISCIPLINE CORE COURSE (DCC)

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
24MA060F	Probability and Statistics	DCC	3	0	0	3	2024

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 for Environmental Engineering problems.	Apply
CO2	Formulate and test hypotheses for Environmental Engineering problems.	Apply
CO3	Apply statistical data analysis tools such as ANOVA and experimental designs for Environmental Engineering problems.	Apply
CO4	Build regression models for Environmental Engineering applications.	Apply
CO5	Identify the principal components for a given data.	Apply
CO6	Apply the concepts of data analysis for a time series.	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:** Random Variables–discrete and continuous random variables, Probability mass functions and probability density functions. Cumulative distribution functions, Mathematical Expectations, mean and variance. Standard discrete distributions- Binomial and Poisson distribution. Standard continuous distributions - Exponential and Normal distribution, Mean and variance (derivation is not required). Computing probability using the above distributions, Fitting of binomial and Poisson distributions.	**10**
II	**Statistical Inference:** Populations and samples. Sampling distribution of the mean (sigma known and unknown), Sampling distribution of the variance (sigma known and unknown). Interval estimation- Confidence interval for mean and variance. Tests of hypotheses:-Null hypothesis and alternative hypothesis, Type I and Type II errors. Test of significance of (i) Mean (ii) Mean of two samples (iii)Proportions (iv) Variance (v) Two variance (vi) Paired t-test (vii) Chi-square test of goodness of fit (viii) Chi-square test for independence.	**9**

III	**Analysis of variance:** Analysis of variance. Completely randomized designs and randomized block designs. Latin square designs Factorial experiments: Two-factor experiments (overview only)	**8**
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)	**9**
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	**9**
	Total Hours	**45**

PROGRAM CORE COURSES (PCC)

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
24CE361A	Environmental Chemistry and Microbiology	PCC	3	0	0	3	2024

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, and radioactive pollutants.	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

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	**10**

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	**9**
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	**8**
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	**10**
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	**8**
	Total hours	**45**

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
24CE361B	Physico-chemical Water and Wastewater Treatment	PCC	3	0	0	3	2024

i) COURSE OBJECTIVES

The course aims to impart in-depth knowledge on water and wastewater treatment techniques and enable to design suitable treatment processes based on achieving the required quality.

ii) COURSE OUTCOMES

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

CO1	Identify the physico-chemical unit operations and process kinetics involved in water and wastewater treatment.	Apply
CO2	Estimate the quantity of wastewater generated for a given population.	Apply
CO3	Analyse water and wastewater quality parameters and suitable treatment processes for the removal of different types of contaminants in water and wastewater.	Analyse
CO4	Apply standard guidelines to design water and wastewater treatment units.	Apply
CO5	Choose advanced technologies for the treatment of water and wastewater based on the nature of contaminants.	Evaluate

iii) SYLLABUS

Introduction to water and wastewater: Physical and chemical quality of water, Sources of water pollution, Wastewater- sources, quantity, collection and conveyance, Sewerage systems, Flow rate and fluctuations of wastewater, Physical and chemical characteristics of wastewater, Effluent standards

Water treatment: Sedimentation, Coagulation and flocculation, Filtration

Wastewater treatment and disposal: Disposal in streams- Dilution and dispersion-self-purification. Screening, Grit removal, Proportional flow weir, Flow Equalization, flotation

Theory and design of physicochemical unit operations for wastewater: Reactors, Aeration-methods of aeration, gas transfer, Two film theory. Adsorption, Disinfection, Disinfection by-products

Advanced water/wastewater treatment: Membrane-based technologies, Desalination, Reverse osmosis, Electrodialysis, Advanced oxidation, catalytic treatment, Electrochemical treatment. Case studies on wastewater treatment in various processes, chemical and allied industries

iii) 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.Stensel, Ryujiro Tsuchihashi, Franklin Burton, *Wastewater Engineering: Treatment and Resource Recovery*, McGraw Hill, 5th edition, ISBN: 978-1259010798, 2014
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) Weber W. J. Jr., *Environmental Systems and Processes: Principles, Modelling and Design*, John Willy and sons, Newyork, 2001
8) Mackenzie L. Davis, *Water and Wastewater Engineering: Design Principles and Practice*, McGraw Hill, 2010
9) John C. Crittenden, R. Rhodes Trussell, David W. Hand, Kerry J. Howe, George Tchobanoglous, *MWH's Water Treatment: Principles and Design*, 3rd Edition, 2012
10) AWWA, *Water Quality and Treatment: A handbook on drinking water,* 6th edition, 2011
11) *Standard Methods for the Examination of Water and Wastewater*, American Public Health Association, American Water Works Association, Water Environment Federation, 23rd edition, 2017
12) IS: 10500:2012 Drinking Water- Specification, Second revision, Bureau of Indian Standards, 2012
13) *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
14) *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	**Introduction to water and wastewater:** Physical and chemical quality of water, Sources of water pollution-domestic, industrial, Water quality standards Wastewater - sources, quantity, collection and conveyance. Storm water-Quantity, Factors affecting. Sewerage systems. Time of concentration, Flow rate and fluctuations of wastewater, variations in concentrations of wastewater constituents Physical and chemical characteristics of wastewater, BOD, COD, Population equivalent, Effluent standards	9
II	**Water treatment:** Sedimentation processes-types of settling, design of sedimentation tanks, Tube settlers Coagulation and flocculation-Types, processes and Design of Clariflocculator Filtration- processes, types. Hydraulics of filtration-losses in filter, Design of filters, Depth filters	9
III	**Wastewater treatment and disposal:** Disposal in streams, Dilution and dispersion, self-purification-factors affecting-physical, chemical, Streeter Phelps equation, oxygen sag curve Screening-Types, Design of bar screen. Grit removal, Design of grit chamber, Proportional flow weir Flow Equalization, Design of equalization tank, flotation- types	9
IV	**Theory and design of physicochemical unit operations for wastewater:** Reactors, Completely mixed batch reactor, Continuous flow stirred tank reactor, Plug flow reactor Aeration- methods of aeration, gas transfer, Two film theory Adsorption- types, adsorption isotherms, Ion exchange Disinfection-Methods, Kinetics, Disinfection by-products	9
V	**Advanced water/ wastewater treatment:** Wastewater treatment by membrane based technologies- Removal of micro pollutants, membrane filtration- Ultra, Nano, Micro filtration. Membrane fouling Desalination, Reverse osmosis, Electrodialysis Advanced oxidation- Fenton process, catalytic treatment, Electrochemical treatment Case studies on wastewater treatment in various processes, chemical and allied industries	9
	Total hours	**45**

PROGRAM ELECTIVE COURSES (PEC)

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
24CE362A	Environmental Impact Assessment and Management	PEC	3	0	0	3	2024

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**: Need for EIA, Evolution of EIA, EIA Guidelines and notification of Govt. of India-Procedure for reviewing Environmental Impact Analysis and statement-Definition, aim, principles, concepts and purposes of EIA-Components or participants of EIA- Public participation in decision making- Projects requiring environmental clearance 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-Factors causing environmental effects in development projects 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-Public Consultation and Participation Environment Impact Statement Preparation Methods of EIA – (Leopold Metric)- Networks Method- Overlays Method- Index Method-Simulation Mode- Cost Benefit Analysis	9

III	**Various Impact Analysis:** Air quality impact analysis - Air pollutants- sources- Atmospheric interaction- Environmental impact assessment methodology Water quality impact analysis – water quality criteria and standards – Environmental setting- modelling - water quality impacts by projects like highways, power plants, mining, agriculture and irrigation, forest management 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- Environmental 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	**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
24CE362B	GIS and Remote Sensing for Environmental Applications	PEC	3	0	0	3	2024

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 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 database management systems (RDBMS)	9
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	9

	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)	
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
24CE362C	Instrumental and Analytical Techniques in Environmental Engineering	PEC	3	0	0	3	2024

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
24CE362D	Geo-Environmental Engineering and Technology	PEC	3	0	0	3	2024

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 Geoenvironmental 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
24CE362E	Environmental Health, Hygiene and Safety	PEC	3	0	0	3	2024

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
Sanitation: Swimming Pool sanitation, Restaurant sanitation, Slaughter house sanitation, Milk plant sanitation and Sanitation of Hospitals. Sanitation related diseases and control measure
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
24CE362F	Mitigation and Adaptation Strategies in Climate Change	PEC	3	0	0	3	2024

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 and mechanisms that have occurred in the climate of earth over the years	Apply
CO2	Identify the global initiatives to address climate change challenges and mitigation measures adopted	Apply
CO3	Analyse the impacts of climate change on various environmental components, locally and globally	Analyse
CO4	Discuss the various adaptation techniques related to climate change issues	Apply
CO5	Choose mitigation strategies and sustainable practices to address climate change	Apply

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: Improving preparedness – Responding to uncertainties- Adapting cities for climate change, role of 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, 2016
2) Mark Masli, *Climate Change: A Very Short Introduction*, Oxford University Press, 3rd edition, 2014
3) David Archer, *The Climate Crisis - An Introductory Guide to Climate Change,* Cambridge University Press, , 2014
4) The Royal Society, National Academy of Sciences, *Climate Change Evidence and Causes*, National Academies Press, 2014
5) Steven Earle, *A Brief History of the Earth's Climate: Everyone's Guide to the Science of Climate Change*, New Society Publishers, 2021
6) Dash Sushil Kumar, *Climate Change – An Indian Perspective*, Cambridge University Press India Pvt. Ltd, 2015
7) Navroz K. Dubash, *Handbook of Climate Change and India*, *Development, Politics and Governance* , Oxford University Press, 2011
8) Burroughs W.J., *Climate Change: A multidisciplinary approach*, Cambridge University Press, 2nd Edition, 2007
9) Barry R.G. and Chorley R.J., *Atmosphere, weather and climate*, Routledge, New York, 8th Edition, 2010
10) Mitsutsune Yamaguchi , *Climate Change Mitigation Balanced Approach to Climate Change,* Springer London Heidelberg New York, 2012
11) Wei-Yin Chen, Toshio Suzuki, Maximilian Lackner , *Handbook of Climate Change Mitigation and Adaptation*, Springer , 2nd edition, 2017
12) Anil Markandya, *Climate Change and Sustainable Development: Prospects for Developing Countries,* Routledge, 1st edition, 2002
13) MoEFCC, *India's long-term low-carbon development strategy*, Ministry of Environment, Forest and Climate Change, Government of India, 2022

V) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to climate change:** Atmospheric structure and composition- components of terrestrial climate system and their interactions. Drivers 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. Greenhouse gases emission scenario. 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, Social Movements	9

	and Global Civil Society	
II	**Impacts of climate change :** Impact on oceans, coastal regions, sea water intrusion Impact on polar regions, melting of ice caps, sea level rise Impact on agriculture, livestock, biodiversity, human health Climate change vulnerability assessment Economics of climate change Case studies on climate change impacts	**9**
III	**Climate change adaptation needs and Sustainable practices:** Geo-informatics in Climate Change Studies- Basic concepts. Improving preparedness – seasonal forecast and early warning- Responding to uncertainties (strategies to adapt an uncertain climate change) Risk & recovery insurance, Food security Adapting cities for climate change: climate resilient infrastructure and planning, role of green infrastructure, changes in National Building codes and standards Ecosystem-based adaptation- nature based solutions- Green technologies for sustainable water management, Case studies	**9**
IV	**Climate change Mitigation:** Characteristics of mitigation in regional and national context; Long term and short-term mitigation options. Energy Conservation and Fuel Efficiency, Renewable energy sources: Solar power, wave power, wind power, hydro power, Geothermal energy, nuclear energy and biofuels Long term low carbon development strategy of India	**9**
V	**Non-energy approaches to climate change mitigation:** Recovery – sequestration - disposal of greenhouse gases Carbon Conversion Technologies: CO_2 Capture, Geological Storage, chemical absorption, membrane capture and gasification technology Mitigation of Flood related issues Case studies on climate disasters and mitigation	**9**
	Total hours	**45**

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
24CE362G	Environmental System Modelling	PEC	3	0	0	3	2024

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
24CE362H	Ecological Engineering	PEC	3	0	0	3	2024

i) COURSE OBJECTIVES

This course aims to expose the students to the fundamental concepts of ecology, biodiversity and the need for its conservation. After this course, students will be able to assess the value of biodiversity and able to analyse the impact of human activities on the ecosystem and suggest mitigation measures to restore the ecosystem

ii) COURSE OUTCOMES

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

CO1	Explain the basic concept and functions of an ecosystem	Understand
CO2	Identify various elements of biodiversity and the causes and impacts of biodiversity depletion	Apply
CO3	Identify community organization and various biogeochemical cycles involved in a community	Apply
CO4	Analyse the effects of pollutants on the ecosystem and the methods for regeneration of degraded ecosystems	Analyse
CO5	Analyse various biodiversity indices	Analyse

iii) SYLLABUS

Fundamentals of Ecology: Scope and application of ecotechnology- Natural eco-systems- Structure and functions of an ecosystem. Ecosystem degradation - Important types of ecosystems in India

Biodiversity: Types and elements of biodiversity- Composition and levels of biodiversity- Biodiversity Hotspots -Diversity in ecosystems and habitat classification. Biodiversity depletion- causes and consequences

Community organization and energy flow

Effects of pollutants on ecosystem: General effects of air, water and land pollutants, biological interactions with pollutants

Ecotechnology for waste treatment: Restoration, Reclamation, and Regeneration of Degraded or Destroyed Ecosystems

Applied Ecology: Estimating Abundance, Species diversity measures, Taxonomy and Biosystematics, Eco-informatics-concepts and principles

iv) REFERENCES

1) Krebs C. J., *Ecological methodology*, Harper Collins Pub. New York, 2nd edition, 1999
2) Kurian Joseph & R. Nagendran, *Essential Environmental studies*, Pearson Education, New Delhi, 2004
3) Michael P., *Ecological methods for laboratory and Field Investigations*, Tata

McGraw Hill Publishing Company Limited, New Delhi, 1990

4) Mitsch, J.W. & Jorgensen, S.E, *Ecological Engineering-An Introduction to Ecotechnology*, John Wiley & Sons, New York, 1989.
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) Eugene P. Odeum, Garry W. Barrett, *Fundamentals of Ecology*, Brooks Cole, 5th edition, 2004
8) Kangas, P.C. and Kangas, P., *Ecological Engineering: Principles and Practice*, Lewis Publishers, New York, 1st edition,2003

V) COURSE PLAN

Module	Contents	No. of hours
I	**Fundamentals of Ecology:** Components of Ecosystem-Structure-function and size of the ecosystem Scope and application of ecotechnology- Relevance of echo technology to human civilization Natural eco-systems ecological Food chains, Food webs and Ecological pyramids- Structure and functions of an ecosystem - Producers, consumers and decomposers Productivity and ecological efficiencies Ecosystem degradation - Resource utilisation- - important types of ecosystems in India (e.g., Wetland ecosystem including estuaries, tidal marshlands, swamps, lakes etc.) Aquatic ecosystems (ponds, lakes, streams, rivers, estuaries, oceans)	9
II	**Biodiversity:** Types and elements of biodiversity- Composition and levels of biodiversity- Biodiversity Hotspots - Concepts of diversity Diversity in ecosystems and habitat classification Biodiversity depletion-causes and consequences- Human impacts on biodiversity. Biodiversity and its conservation ecosystems - speciation and extinctions	9
III	**Community organization and Energy flow:** Nutrient cycles-Energy Flow- Biogeochemical Cycles-Trophic Relations-Food chain The energy cycle - Integration of cycles in nature- Ecological Succession-Kinds of Succession (Hydrarch and Xerarch) Community Organization- Ecological Niche-Interactions between species-Competition-Predation-Mutualism-Commensalism-Parasitism-Allelopathy	9

IV	**Effects of pollutants on ecosystem:** General effects of air, water and land pollutants, biological interactions with pollutants. Ecosystem responses to deoxygenating, nutrient enrichment, pesticides, hydrocarbons etc. Ecotechnology for waste treatment- wetlands and ponds. Restoration, Reclamation, and Regeneration of Degraded or Destroyed Ecosystems.	**9**
V	**Applied Ecology:** Estimating Abundance: -Mark and Recapture Method -Quadrat and Line Transects-Distance and Removal Methods-Trapping and Collection Techniques-Census technique for Avifauna and Wildlife Species Diversity measures- Species Richness- Species Heterogenicity (Simpson's Indices, Shannon-Wiener Indices)-Vegetational Profile assessments Taxonomy and Biosystematics Eco-informatics-concepts and principles	**9**
	Total hours	**45**

Course Code	Course Name	Course Type		L	T	P	Credit	Year of Introduction
24CE362I	Air Pollution and Control Technologies	PEC		3	0	0	3	2024

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
24CE362J	Advanced Wastewater Treatment Technologies	PEC	3	0	0	3	2024

i) COURSE OBJECTIVES

The course aims to enrich the understanding of need and applications of advanced wastewater treatment systems

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, nanoparticles. Applications

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. Gamma ray, X-ray and electron beam based processes

Filtration techniques: Filtration, Microfiltration – Ultrafiltration - Nanofiltration – Reverse Osmosis – Electrodialysis – Pervaporation

Membrane reactors: Membrane manufactures – Membrane Module / Element designs – Membrane System components – Design of Membrane systems. Membrane Bioreactors- MBR Design Principles. Microbial Fuel Cell- principle, components, Applications, Limitations

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**: Limitations of conventional wastewater treatment methods Purpose and benefits of advanced wastewater treatment Chemical clarification, Electrocoagulation, Demineralization, ion exchange, Ammonia stripping	9
II	**Sorption Techniques:** Types of sorbents, Sorption kinetics and isotherm models Activated carbon adsorption and regeneration Manufacture of activated carbon Characteristics of carbon used in wastewater treatment Biosorption- Photo-catalytic adsorbents -nanoparticles Applications: Removal of chemical fertilizers, heavy metals Desorption Techniques	9

III	**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 Gamma ray, X-ray and electron beam based processes	**9**
IV	**Filtration Techniques:** Filtration, theory and performance of in-depth filters, Filter problems and their solutions, Types of in-depth filters, surface filters Microfiltration – Ultrafiltration - Nanofiltration – Reverse Osmosis – Electrodialysis - Pervaporation	**9**
V	**Membrane Reactors:** Membrane manufacture – Membrane Module / Element designs – Membrane System components – Design of Membrane systems Membrane Bioreactors- Biotreatment Fundamentals, Biomass Separation, MBR Principles, Fouling and Fouling Control, MBR Design Principles Microbial Fuel Cell: principle, components, Applications, Limitations	**9**
	Total hours	**45**

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
24CE362K	Environmental Biotechnology and Bioremediation	PEC	3	0	0	3	2024

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
24CE362L	Environmental Hydrology	PEC	3	0	0	3	2024

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
24CE362M	Contaminant Transport and Remediation	PEC	3	0	0	3	2024

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 modelling	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 - origin, age, distribution, 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 modelling, Introduction to Groundwater Modelling software

Remediation measures

iv) REFERENCES

1) Randall J. Charbeneau, *Ground water Hydraulics and Pollutant Transport*, 1st edition, 2006
2) D. K. Todd and L. W. Mays, *Groundwater*, John Wiley & Sons, Inc., 3rd edition, 2004
3) C. W. Fetter, *Applied Hydrogeology,* Prentice Hall, Inc., 4th edition, 2001
4) C. W. Fetter*, Contaminant Hydrogeology*, Waveland Press, 2nd edition, 2008

5) P. A. Domenico and F. W. Schwartz, *Physical and Chemical Hydrogeology*, , John Wiley & Sons, Inc., 2nd edition,1998
6) F. W. Schwartz and H. Zhang, *Fundamentals of Groundwater*, John Wiley & Sons, Inc., 1st edition, 2003
7) A. K. Rastogi, *Numerical Groundwater Hydrology*, Penram International Publishing (India) Pvt. Ltd., 2007
8) VedatBatu, *Applied Flow and Solute Transport Modelling in Aquifers*, Taylor and Francis/ CRC Press, 1st edition, 2006
9) 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 Conservative Contaminant - Estimation of dispersion coefficient (Problems) Chemical Reactions - Equilibrium controlled sorption - Estimation	9

	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	
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
24CE362N	Environmental Toxicology	PEC	3	0	0	3	2024

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,	9

	Influence of ecological factors on the effects of toxicity	
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, butylayedhydroxytolune, 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, The 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
24CE362O	Applications of AI and ML in Environmental Engineering	PEC	3	0	0	3	2024

i) COURSE OBJECTIVES

The course delves into the integration of AI and ML techniques in solving complex environmental engineering problems. Students will explore how these technologies can be applied to model, predict and optimize environmental systems. The course details topics such as data-driven modelling, environmental data analysis and the development of intelligent systems for sustainable management of natural resources.

ii) COURSE OUTCOMES

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

CO 1	Explain the fundamental concepts of AI and ML.	Understand
CO 2	Explain data preprocessing techniques in machine learning.	Understand
CO 3	Demonstrate the working of classifier models like Neural Networks.	Understand
CO 4	Develop ML algorithms for environmental applications, build predictive models and optimise environmental processes.	Apply
CO 5	Analyse real world case studies and research to assess the impact of AI and ML on environmental sustainability.	Apply

iii) SYLLABUS

Introduction to Artificial Intelligence and Machine Learning

Classification-Concepts

Artificial Neural Networks

Applications in Environmental Systems

Tools and Technologies for Environmental AI/ML

Case Studies

iv) REFERENCES

1) Shai Shalev-Shwartz and Shai Ben-David, *Understanding Machine Learning* Cambridge University Press, 3rd edition, 2015, ISBN 978-1107512825
2) Trevor Hastie, Robert Tibshirani and Jerome Friedman, *The Elements of Statistical Learning (ESL),* Springer, 2nd edition, 2016, ISBN 978-0387848570
3) Ian Goodfellow, Yoshua Bengio, Aaron Courville, and Francis Bach*, Deep Learning Adaptive Computation and Machine Learning,* MIT Press, 2017, ISBN 978-0262035613

4) M. Z. Naser, *Machine Learning for Civil & Environmental Engineers: A Practical approach to Data-Driven Analysis, Explainability and Causality*, Wiley, 2023

5) S. Araghinejad, *Data-driven Modelling: using MATLAB in water resources and environmental engineering*, Springer, 2014

6) A. I. J. Forrester, A. Sobester, and A. J. Keane, *Engineering Design via Surrogate Modelling: A Practical Guide*, John Wiley & Sons, 2008

7) T. Hastie, J. Friedman, and R. Tisbshirani, *The Elements of Statistical Learning: Data Mining, Inference, and Prediction*, Springer, 2017

8) V. N. Vapnik, The Nature of Statistical Learning Theory. New York: Springer, 2000

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to AI and ML :** Introduction to learning, types of learning, role of learning, Machine learning, supervised learning, unsupervised learning, semi-supervised learning, Applications of machine learning. Types of data, attributes, types- nominal, ordinal, interval, ratio Similarity measures: Euclidian, Manhattan distance, Cosine similarity. Dimensionality reduction techniques- Principal Component Analysis, Attribute Subset Selection, Parametric data reduction, Histograms	9
II	**Classification:** Concepts, Classifier performance- Accuracy, Error rate, Precision, Recall Decision trees, Information Gain, Gain Ratio, Gini Index, ID3 Algorithm, Bayes Theorem, Naive Bayesian Classification.	9
III	**Artificial Neural Networks:** Basics, learning perception model, Multi layer feed forward network, back propagation. Deep Neural Networks. Case study	9
IV	**AI and ML applications in Environmental Systems:** Environmental monitoring and assessment, Resource management and optimisation, Climate change and environmental impact analysis Tools and Technologies for Environmental AI/ML: Software and programming tools, Environmental data platforms and APIs	9
V	**Case Studies:** Analysis of successful AI/ML applications, challenges and solutions in applying AI/ML to environmental problems, Emerging trends and future directions	9
	Total Hrs.	**45**

RESEARCH METHODOLOGY & IPR (MCC)

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
22MC061A	Research Methodology & IPR	RM	2	0	0	2	2022

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, Literature survey, 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
24CE369A	Environmental Monitoring Lab I	LBC	0	0	2	1	2024

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	2
2	Analysis of Residual Chlorine and Iron in a given water sample	2
3	Analysis of Chlorides and Sulphates in a given water sample	1
4	Analysis of Nitrate and Phosphate in a given water sample	2
5	Analysis of BOD and COD in a given water sample	3
6	Analysis of oil and grease in a given water sample	2
7	Analysis of Heavy metals (any two) in a given sample	2
8	Study of instruments and equipment in a Microbiology Lab	1
9	Culture media preparation and Pure culture techniques in Microbiology	2
10	Preparation of Gram stained smear of bacteria	2
11	Isolation of microorganisms from soil ,water & air	2
12	Determination of total bacterial population by standard plate count technique	2
13	Analysis of coliforms and *E coli* by MPN and Membrane filtration technique	3
14	Environmental Engineering software	4
	Total hours	**30**

DETAILED SYLLABI (M2)
M.Tech ENVIRONMENTAL SCIENCE AND ENGINEERING
SEMESTER II

DISCIPLINE CORE COURSES (DCC)

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
24CE360A	Solid and Hazardous Waste Management	DCC	3	0	0	3	2024

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, http://cpheeo.gov.in/cms/manual-on-municipal-solid-waste-management-2016.php

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

(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 Mechanical volume reduction– chemical volume reduction- mechanical size reduction. Waste transformation through combustion and composting, Aerobic composting, Anaerobic methods for materials recovery and treatment. Recycling of plastic materials and metals. Energy recovery options – Incinerators, RDF	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**

PROGRAMME CORE COURSES (PCC)

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
24CE361C	Biological Wastewater Treatment	PCC	3	0	0	3	2024

i) COURSE OBJECTIVES:

Biological wastewater treatment covers the different biological methods of wastewater treatment and related issues. The course is designed to create awareness among the students about the importance of wastewater treatment, and also to develop skill in the basic design of unit operations and unit processes in the biological wastewater treatment. This course also gives awareness to the student about the management of the sludge resulting from the treatment of wastewater.

ii) COURSE OUTCOMES:

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

CO 1	Identify the types of biological processes, and role of microbial metabolisms in wastewater treatment	Apply
CO 2	Apply the Menten and Monod models of treatment kinetics and methods of evaluation of kinetics constants	Apply
CO 3	Analyse the process design considerations of different types of biological treatment units	Analyse
CO 4	Apply the guidelines for the design of biological treatment units for given specifications	Apply
CO 5	Identify suitable treatment and disposal methods of sludge from biological treatment processes	Apply

iii) SYLLABUS:

Introduction to biological 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 and disposal

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) Mark J. Hammer and Mark J. Hammer Jr., *Water and Wastewater Technology*, Prentice Hall of India Pvt. Ltd., 4th edition, 2008

3) Arcadio P. Sincero and Gregoria A. Sincero, *Environmental Engineering: A Design Approach*, Pearson Education Services Pvt. Ltd., 2nd edition, 2016
4) Soli J. Arceivala and Shyam R. Asolekar, *Wastewater Treatment for Pollution Control and Reuse*, McGraw Hill Education, 3rd edition, 2007
5) Syed R. Qasim, *Wastewater Treatment Plants- Planning, Design & Operation*, Routledge, 2nd edition, 2017
6) Benefield, L.D. and Randall C.W., *Biological Processes Design for wastewaters*, Prentice-Hall, Inc. Eaglewood Cliffs, 1982
7) Grady Jr. C.P.L and Lin H.C., *Biological wastewater treatment: Theory and Applications*, Marcel Dekker, Inc New York, 3rd edition, 2011
8) Quano, *Principles of Wastewater Treatment*, Vol. I, Oxford and IBH
9) *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	Objectives of biological treatment – Role of enzymes in wastewater treatment, Enzyme kinetics, Factors affecting rate of reactions Types of biological processes for wastewater treatment Different microbial metabolisms Bacterial growth patterns	**9**
II	Microbiological treatment kinetics and flow regimes – Michaelis- Menten and Monod models Rate of biomass growth with soluble substrates – Kinetic coefficients – Effect of temperature – Oxygen requirements – Biomass yield – Observed yield Kinetic constants evaluation of biological treatment-- problems	**9**
III	Aerobic biological treatment – Attached growth and suspended growth treatment systems – Modelling suspended growth treatment process Activated sludge process – Description – Various types – Methods of aeration – Microbiology – Process analysis – Process design considerations –Design of ASP-- Operational difficulties – Modifications Sequencing Batch Reactor – Process description and operation—Design.	**9**
IV	Trickling filter – Filter classifications – Microbiology – Process design considerations – Design of physical facilities – Necessity of Recirculation – NRC Equation – Design of Trickling filter--Operational difficulties, High rate trickling filters-Problems Aerated lagoons – Types – Process design considerations. Stabilization ponds – Classification – Design considerations.	**9**
V	Sludge treatment and disposal – Characteristics of sludge –	**9**

	Sludge processing – Preliminary operations – Thickening – Stabilization Aerobic sludge digestion - Anaerobic sludge digestion – Composting of sludge Conditioning of sludge– Dewatering - Heat drying - Incineration-- Wet air oxidation – Land application-- conveyance, storage and disposal by dilution	
	Total hours	**45**

INDUSTRY ELECTIVE COURSES

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
24CE366A	Industrial Effluent Management	IEC	3	0	0	3	2024

i) COURSE OBJECTIVES:

The goal of this course is to introduce the students to industry practices on the management of industrial wastewater. The course details about the various terms used in industrial wastewater treatment and the different steps involved in treatment of industrial wastewater. Students will also gain knowledge about the nature of effluents discharged from various typical industries and how the same is managed with minimum impact on the environment

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 and suggest suitable pollution prevention methods	Evaluate
CO3	Identify suitable contaminant removal methods for industrial effluent	Apply
CO4	Analyse the common industrial processes such as rinsing, degreasing, descaling and deinking and suggest suitable waste minimization methods	Analyse
CO5	Evaluate treatment methods and pollution prevention methods for specific industries based on the nature of waste	Evaluate

iii) SYLLABUS:

Industrial pollution- sources, sampling, characteristics and effects

Development of industrial effluent treatment system and pollution prevention

Effluent treatment methods

Typical industrial processes and effluent management

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

iv) REFERENCES:

1) Ogbiye Adebanji , *Management of Industrial Effluents- an Engineering Approach*, LAP Lambert Academic Publishing, 2016

2) N. Manivasakam, *Industrial Effluents- Origin, Characteristics, Effects, Analysis and Treatment*, Chemical Publishing Co Inc. US, 2016

3) N.L. Nemerow, *Theories and practices of Industrial Waste Treatment*, Addison-Wesley Publishing Company, 2007

4) N.L.Nemerow, *Industrial Waste Treatment: Contemporary Practice and Vision for the future*, Butterworth-Heinemann Inc., 1st edition, 2006

5) Woodard and Curran, Inc., *Industrial Waste Treatment Handbook*, Butterworth-Heinemann Ltd., 2nd 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) Ruth Hillary, *Environmental Management Systems and Cleaner Production*, Wiley, New York, 1st edition, 1997

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 Disposal by dilution – Streeter Phelps formulations - numerical problems Effects of industrial effluents on streams, sewer, land, sewage treatment plants and human health Stream sampling – Frequency, number of samples, sampling points, methodology, data to be obtained, precautions, time of sampling, statistical handling of data, overall objectives	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 Analysis of manufacturing process, pollution prevention program,	9

	wastewater characterisation 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 inorganic and inorganic dissolved solids Removal of heavy metals, oil, grease, biodegradable organics, toxic organics, cyanide, fluoride Sludge handling and disposal Combined treatment of industrial and municipal effluents	**9**
IV	**Typical industrial processes and effluent management:** Chemical descaling, degreasing, die casting Electroplating, rinsing, deinking Food processing, meat processing Environmental standards related to prevention and control of industrial effluents from – Electroplating and anodising industries, Meat industry, Food processing industry, Tannery, Large Pulp and Paper industry	**9**
V	**Specific industries and effluent management:** Sources and characteristics of industrial effluents, wastewater treatment flow sheets and waste minimization strategies for selected industries - Textile, Tannery, Dairy, Pulp and Paper, Paper recycling Case studies	**9**
	Total hours	**45**

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
24CE366B	Circular Economy	IEC	3	0	0	3	2024

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 aims to acquaint students about the need of businesses related to circularity and to create zeal among students to pursue research and development and entrepreneurship in this domain.

ii) COURSE OUTCOMES:

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

CO1	Explain the concepts and methodologies associated with Circular Economy	Understand
CO2	Apply the concept of circular economy to solve environmental engineering problems	Apply
CO3	Apply the principles of circularity for development of circular business models	Apply
CO4	Explain the legal and policy framework related to circular economy	Apply

iii) SYLLABUS:

Introduction to Circular Economy, Characteristics of Circular Economy

Circular design, Innovation and Assessment

Case Studies

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, 2020

8) Lerwen Liu, Seeram Ramakrishna, *An Introduction to Circular Economy*, Springer, Singapore 2021

9) 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, Development of Concept of Circular Economy, A differential - Linear vs Circular Economy Purpose of 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, Waste Reduction, Reducing negative externalities, Butterfly diagram, Concept of Loops	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, Solid Waste Management / Wastewater, Plastics: A case study, EPR: polluters pay principle, Industrial symbiosis/ Eco-parks, Case studies on Technological Innovations	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
24CE366C	Environmental Nanotechnology	IEC	3	0	0	3	2024

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 wastes: 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/	9

	modified structures/ devices. Environmental benefits of nanomaterials 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**

INTERDISCIPLINARY ELECTIVE COURSE

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
24CE365A	Sustainable Technologies and Cleaner Production	3	0	0	3	3	2024

i) COURSE OBJECTIVES

The aim of this course is to educate students about Cleaner Production Techniques and its application, leading to pollution minimization in a sustainable manner. Students will gain knowledge in the domains of environmental, economic and technological aspects of cleaner production methods.

ii) COURSE OUTCOMES

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

CO1	Discuss the significance of pollution prevention and cleaner production concepts in engineering	Understand
CO2	Identify the step-by-step procedure for cleaner production methodology	Apply
CO3	Apply sustainable and innovative technologies for engineering applications	Apply
CO4	Discuss Life Cycle Assessment and Environmental Management Systems	Apply
CO5	Apply the concept of pollution prevention and cleaner production techniques in industrial production	Apply

iii) SYLLABUS

Concept of Pollution Prevention and Cleaner Production

Cleaner Production Methodology

Sustainable Technologies

Life Cycle Assessment (LCA) and Environmental Management Systems (EMS)

Case Studies on Cleaner Production

iv) REFERENCES

1) Misra K. B., *Clean Production: Environmental and Economic Perspectives,* Springer-Verlag Berlin, 2012
2) Freeman, H.M, *Industrial Pollution Prevention Handbook*, McGraw Hill, 1st edition, 2017
3) Ruth Hillary, *Environmental Management Systems and Cleaner Production*, Wiley,1st edition, 1997
4) Paul L. Bishop, *Pollution Prevention: Fundamentals and Practice*, Waveland Pr Inc.,

2004

5) Marry Ann Curran, *Environmental Life Cycle Assessment*, McGraw Hill Education, 1996
6) World Bank Group, *Pollution Prevention and Abatement Handbook-Towards Cleaner Production*, World Bank and UNE, Washington D.C., 1998
7) James G. Mann and Y.A.Liu, *Industrial Water Reuse & Wastewater Minimization*, McGraw Hill Professional, 1st edition, 1999

v) COURSE PLAN

Module	Contents	No. of hours
I	**Concept of Pollution Prevention and Cleaner Production:** Importance - Historical Evolution – Benefits - Promotion - Barriers – Role of Industry, Government and Institutions - Environmental Management Hierarchy Source Reduction techniques – Process and Equipment Optimization, Reuse, Recover, Recycle, Raw material substitution Industrial Ecology – Pollution Prevention (PP) and Cleaner Production (CP) in achieving Sustainability- Prevention versus Control of Industrial Pollution	9
II	**Cleaner Production Methodology:** Theory of cleaner production – Effect, Need and Barriers for Cleaner Production Six step methodology for Cleaner Production - Total quality management - Project development and implementation – Overview of CP Assessment steps and skills, Preparing the site, Information gathering and Flow diagram, Material balance, PP and CP Option generation, Technical and Environmental Feasibility analysis, Total Cost analysis - PP and CP Financing Establishing a Program - Organizing a Program- Preparing a program plan - Measuring progress – Pollution Prevention and Cleaner Production Awareness Plan - Waste Audit- Environmental Statement	9
III	**Sustainable technologies:** Greenhouse gases and carbon credit- carbon sequestration- Sustainable development through trade - carbon trading – SDGs and cleaner production-carbon capture Green technologies – Green technologies for sustainable water management, ZLD processes, Green computing, Intelligent Construction Machinery Sustainable Energy - Energy production from biomass and wastes and energy conservation	11
IV	**Life Cycle Assessment and Environmental Management Systems :** Economic, Environmental, and Social Performance Indicators LCA - Steps in conducting LCA - Life Cycle Costing Environmental certifications - Eco labelling – Energy star Certified	9

	Carbon Neutral - The Global Organic Textile Standard – USDA Organic Green building certification – national and international Good housekeeping – checklists and implementation International Environmental Standards - ISO 14001 Eco Warranty	
V	**Case Studies on Cleaner Production:** Cleaner production case studies - Industrial Applications of PP and CP, LCA, EMS and Environmental Audits in the following industries : Textile processing industry, Distillery, Paper mill, Dye manufacturing industry, Construction industry, Petroleum industry	**9**
	Total hours	**45**

LABORATORY COURSES (LBC)

Course Code	Course Name	Course Type	L	T	P	Credit	Year of Introduction
24CE369B	Environmental Monitoring Lab II	LBC	0	0	2	1	2024

i) COURSE OBJECTIVES:

The objective of this course is to enable students to familiarise 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	2
2	Analysis of Nitrates in soil	2
3	Analysis of Sulphates in soil	2
4	Analysis of soil pH & Chloride content	2
5	Analysis of sediments - pH ,ORP	2
6	Analysis of sediments - heavy metals	2
7	Analysis of Calcium in a given water sample	2
8	Analysis of Potassium in a given water sample	1
9	Analysis of Sodium in a given water sample	1
10	Analysis of Lithium in a given water sample	1
11	Analysis of Noise pollution	2
12	Analysis of air quality parameters - PM 2.5 & PM 10	2
13	Modelling techniques-Air quality & water Quality	3
14	Modelling techniques- Climate change & Life Cycle Analysis	3
15	Modelling techniques- Water Supply & Sewer design	3
	Total hours	**30**

M.Tech ENVIRONMENTAL SCIENCE AND ENGINEERING

SEMESTER III

List of MOOC Courses					
Sl. No.	**Course Code**	**Course Name**	**Duration**	**Offering Platform**	**Course Institution**
1.	noc24-ce88	Environmental Modelling and Simulation	12weeks	nptel	IITR
2.	noc24-ce100	An introduction to climate dynamics, variability and monitoring	12weeks	nptel	IITH
3.	noc24-ce102	Indoor Air Pollution- Sources, Effects, Monitoring, Control and Modelling	12weeks	nptel	IITH

LIST OF AUDIT COURSES

Sl. No.	Course Name
1	English for Research Paper Writing
2	Business Communication and Presentation Skills
3	Ethics and Human Values
4	Pedagogy Studies
5	Stress Management by Yoga
6	Personality Development through Life Enlightenment Skills
7	Cost Management of Engineering Projects
8	Operations Research
9	Composite Materials
10	Energy from Waste
11	Entrepreneurship Development
12	Principles of Automation
13	Universal Human Values

ASSESSMENT PATTERN
(2022 SCHEME)

(i) CORE COURSES

Evaluation can include application, analysis and design based questions (for both Continuous internal evaluation and End semester examination).

Continuous Internal Evaluation: 40 marks

Micro project/ Course based project: 20 marks
(The project shall be done individually. Group projects not permitted)

Course based task/ Seminar/Quiz: 10 marks

Continuous Assessment Test (CAT), 1 No: 10 marks
(CAT shall include three modules, approximately 60% of the syllabus)

End Semester Examination (ESE): 60 marks

The ESE shall be conducted by the CoE. The examination will be for 150 minutes.

The question paper will have two parts; Part A and Part B.

Part A contain 5 questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students are required to answer all questions.

Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/ practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module, of which student are required to answer any five. Each question shall carry 7 marks.

(ii) ELECTIVE COURSES

Evaluation can include application, analysis and design based questions (for both Continuous internal evaluation and End semester examination).

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed Original publications: 15 marks
(minimum 10 publications shall be referred)

Course based task/ Seminar/ Data collection and interpretation: 15 marks

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

(CAT shall include three modules, approximately 60% of the syllabus)

End Semester Examination: 60 marks

The ESE will be conducted by the CoE. The examination will be for 150 minutes.
The question paper will have two parts; Part A and Part B. Part A will contain 5 questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students are required to answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/ practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module, of which student are required to answer any five. Each question shall carry 7 marks.

(iii) RESEARCH METHODOLOGY & IPR/ AUDIT COURSE

Continuous Internal Evaluation: 40 marks

Course based task: 15 marks

Seminar/Quiz: 15 marks

Continuous assessment Test (CAT), 1 No: 10 marks
(CAT shall include three modules, approximately 60% of the syllabus)

End Semester Examination: 60 marks

The ESE will be conducted by the CoE. The examination will be for 150 minutes.

The question paper will contain 7 questions, with minimum one question from each module, of which students are required to answer any five. Each question shall carry 12 marks.

(iv) INTERNSHIP

Internship for the M.Tech students is accepted as a matter of policy in ensuring the immersive learning by the students. 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. An internship may be compensated or non-compensated by the organization providing the internship. The internship has to be meaningful and mutually beneficial to the intern and the organization. It is important that the objectives and the activities of the internship program are clearly defined and understood. The internship offers the students an opportunity to

(i) Gain hands-on industrial or organizational exposure

(ii) Integrate the knowledge and skills acquired through the coursework

(iii) Interact with professionals and other interns, and

(iv) Improve their presentation, writing, and communication skills.

Internship often acts as a gateway for final placement for many students.
A student shall opt for carrying out the Internship at an Industry/ Research Organization or at another institute of higher learning and repute (Academia). The organization for Internship shall be selected/ decided by the students on their own after getting approval from the respective PG Programme Coordinator. Every student shall be assigned an internship Supervisor/ Guide at the beginning of the Internship. The training shall be related to their specialization and must be carried out immediately after the second semester ESE, for duration of six to eight weeks. On completion of the course, the student is expected to be able to develop skills in facing and solving the problems experiencing in the related field.

Objectives

- Exposure to the industrial environment, which cannot be simulated in the class room and hence creating competent professionals for the industry.
- Provide possible opportunities to learn understand and sharpen the real time technical/ managerial skills required at the job.
- Exposure to the current technological developments relevant to the subject area of training.
- Create conducive conditions with quest for knowledge and its applicability on the job.
- Understand the social, environmental, economic and administrative considerations that influence the working environment.
- Expose students to the engineer's responsibilities and ethics.

Benefits of Internship

Benefits to Students

- An opportunity to get hired by the Industry/ organization.
- Practical experience in an organizational setting & Industry environment.
- Excellent opportunity to see how the theoretical aspects learned in classes are integrated into the practical world. On-floor experience provides much more professional experience which is often worth more than classroom teaching.
- Helps them decide if the industry and the profession is the best career option to pursue.
- Opportunity to learn new skills and supplement knowledge.
- Opportunity to practice communication and teamwork skills.
- Opportunity to learn strategies like time management, multi-tasking etc in an industrial setup.
- Makes a valuable addition to their resume that enhances their candidacy for higher education/ placement.
- Creating network and social circle and developing relationships with industry people.
- Provides opportunity to evaluate the organization before committing to a fulltime position.

Benefits to the Institute

- Build industry academia relations.
- Makes the placement process easier.
- Improve institutional credibility & branding.
- Helps in retention of the students.
- Curriculum revision can be made based on feedback from Industry/ students.
- Improvement in teaching learning process.

Benefits to the Industry

- Availability of ready to contribute candidates for employment.
- Year round source of highly motivated pre-professionals.
- Students bring new perspectives to problem solving.
- Visibility of the organization is increased on campus.
- Quality candidate's availability for temporary or seasonal positions and projects.
- Freedom for industrial staff to pursue more creative projects.
- Availability of flexible, cost-effective workforce not requiring a long-term employer commitment.
- Proven, cost-effective way to recruit and evaluate potential employees.
- Enhancement of employer's image in the community by contributing to the educational enterprise.

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

- All the students need to go for internship for minimum duration of 6 weeks and a maximum duration of 8 weeks.
- Students can take up mini projects, assignments, case studies, and so on by discussing it with authority from the host organization/ industry concerned and can work on it during the internship.
- All students should compulsorily follow the rules and regulations as laid by 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 industry.
- Students have to 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
    - ✓ Internship certificate

- ✓ Feedback from employer/ internship mentor
- ✓ Proof of Stipend received (if applicable).

Total Marks 100: The marks awarded for the Internship will be on the basis of

(i) Evaluation done by the Industry
(ii) Student's diary/ Daily log
(iii) Internship Report and
(iv) Comprehensive Viva Voce.

Continuous Internal Evaluation: 50 marks

Student's diary/ Daily Log: 25 Marks
Evaluation done by the Industry: 25 Marks

Student's Diary/ Daily Log: **25 marks**

The main purpose of writing Student's Diary/ Daily Log 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 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. The daily training diary should be signed after every day by the supervisor/ in charge of the section where the student has been working. The diary should also be shown to the Faculty Mentor visiting the industry from time to time and got ratified on the day of his visit. Student's diary will be evaluated on the basis of the following criteria:

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

The format of Student's Diary/ Daily Log

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

<u>The format of Student's attendance Sheet</u>

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 ....

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

Evaluation done by the Industry: 25 marks

Format for Supervisor Evaluation of Intern

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 - 0.50 mark) Satisfactory (0.50 – 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

End Semester Evaluation (External Evaluation): 50 Marks

Internship Report: 25 Marks

Comprehensive Viva Voce: 25 Marks

Internship Report: 25 marks

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 mentor. The student may contact Industry Supervisor/ Faculty Mentor for assigning special topics and problems and should prepare the final report on the assigned topics. Student's Diary/ Daily log will also help to a great extent in writing the industrial 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: 25 marks

Viva Voce will be done by a committee comprising Faculty mentor, PG Programme Coordinator and an external expert (from Industry or research/ academic Institute). This committee will be evaluating the internship report also.

(v) 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.

(vi) INDUSTRY BASED ELECTIVES/ INTERDISCIPLINARY ELECTIVES

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 did not match with the Industry requirements, especially in the field of latest topics.

Interdisciplinary knowledge is critical for connecting students with current industry trends, where multitasking is the norm. Interdisciplinary knowledge aids in the bridge building process between academic institutions and industry. It aids students in expanding their knowledge and innovating by allowing them to create something new. While 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. Other courses' knowledge, on the other hand, can assist them to deal with any scenario more effectively. Interdisciplinary courses may be one approach to address such needs, as they can aid in the enhancement of engineering education and the integration of desirable specialized subjects into the current engineering education system. This will enable students to fulfill the current industry demands. Students with multi-disciplinary knowledge and projects are more likely to be placed in top industries, according to the placement trend. The future of developing engineers will be influenced by their understanding of emerging technology and interdisciplinary approaches.

Rapid technological advancements and the onset of the fourth industrial revolution 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 other departments/ Industries that cover a wide range of highly relevant topics such as artificial intelligence, internet of things, big data, automation, and other software or other relatable courses. In the case of Industry based electives the course shall be handled by the expert in the industry and the faculty in the college.

Assessment pattern for Interdisciplinary electives:

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed Original publications: 15 marks
(minimum 10 publications shall be referred)

Course based task/ Seminar/ Data collection and interpretation: 15 marks

Continuous assessment Test (CAT), 1 No: 10 marks
(CAT shall include three modules, approximately 60% of the syllabus)

End Semester Examination: 60 marks

The ESE will be conducted by the CoE. The examination will be for 150 minutes.

The question paper will have two parts; Part A and Part B.

Part A will contain 5 questions with 1 question from each module, having 5 marks for each

question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students).Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/ practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student are required to answer any five. Each question shall carry 7 marks.

Assessment pattern for Industry based electives:

Continuous Internal Evaluation: 40 marks

The continuous internal evaluation will be done jointly by the expert in the Industry and the faculty in the college.

Micro project/ Course based project: 20 marks
(The project shall be done individually. Group projects not permitted)

Course based task/Seminar/Quiz: 10 marks

Continuous assessment Test (CAT), 1 No: 10 marks
(CAT shall include three modules, approximately 60% of the syllabus)

End Semester Examination: 60 marks

The ESE will be conducted by the CoE. The examination will be for 150 minutes.
The question paper shall be prepared jointly by the expert in the industry and the faculty in the college. The question paper will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question shall carry 12 marks.
The first valuation of the answer scripts shall be done by the expert in the Industry handling the course, and the second valuation shall be done by the faculty in the college. In the situation when the expert in the Industry is not available for first valuation, the college shall appoint an expert for this valuation.

(vii) MOOC COURSES

The MOOC course shall be considered only if it is conducted by the agencies namely AICTE/ NPTEL/ SWAYAM/ NITTTR. The MOOC course should have a minimum duration of 8 weeks and the content of the syllabus shall be enough for at least 40 hours of teaching. The course should have a proctored/ offline end semester examination. The students can do the MOOC according to their convenience starting from first semester, but shall complete it by fourth semester. The list of MOOC courses will be provided by the concerned BoS if at least 70% of the course content match 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.
A certificate of successful completion of the MOOC course (as per the evaluation pattern of the respective agency conducting the MOOC) is to be duly produced for verification. Two credits will be awarded to all students whoever successfully completes the MOOC course.

(viii) MINIPROJECT

Mini project can help to strengthen the understanding of student's fundamentals through application of theoretical concepts and to boost their skills and widen the horizon of their

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 Dissertation/ Research project. Students should identify a topic of interest in consultation with PG Programme Coordinator that should lead to

their Dissertation/ Research project. Demonstrate the novelty of the project through the results and outputs. The progress of the mini project is evaluated based on three reviews, two interim reviews and a final review. A report is required to be submitted before the final review. Mini project has continuous internal assessment for a total of 100 marks.

Interim evaluations: 40 marks

First evaluation: 20 marks

Second evaluation: 20 marks

Final evaluation: 60 marks

Evaluation by a Committee: 30 marks

The committee will evaluate the demonstration of functionality/ specifications, clarity of presentation, oral examination, and knowledge on the project work.

Report: 10 marks

The committee will evaluate the technical content, and adequacy of references. Permitted plagiarism level is not more than 25%.

Supervisor/ Guide: 20 marks

(ix) DISSERTATION/ RESEARCH PROJECT

Research Project:

Students selected for track 2 shall carry out their Research project only in the college, under the guidance of a supervisor assigned by the DLAC.

Dissertation:

All categories of students in track 1 are to carry out the Dissertation in the college or can work either in any CSIR/ industrial R&D organization/ any other reputed Institute which have facilities for dissertation work in the area proposed.

Dissertation outside the Institute:

For doing Dissertation 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 Dean (PGSR), on recommendation from the concerned DLAC.
- Students availing this facility should continue as regular students of the College.
- Facilities required for doing the dissertation shall be available in the Organization/ Industry (A certificate stating the facilities available in the proposed organization and 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 is associated for doing the Dissertation work. The external supervisor shall be with a

minimum Post graduate degree in the related area.

- The course work in the 3rd semester is to be completed as per the curriculum requirements:

  (i) MOOC can be completed as per the norms specified in this curriculum.

  (ii) Audit course is to be carried out either in the College or by self-learning. However, for self-learning students, all assessments shall be carried out in the college as in the case of regular students.

- 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 (online/ offline) during all stages of evaluation of the Dissertation.

Internship leading to Dissertation:

The students who, after completion of 6 to 8 weeks internship at some reputed organization, are allowed to continue their work as dissertation for the third and fourth semester can do so only after getting approval from Dean (PGSR) on recommendation from the concerned 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 Dissertation. These students will be continuing as regular students of the college in third semester for carrying out all academic requirements as per the curriculum/ regulation. However, they will be permitted to complete their Dissertation in the Industry/ Organization (where they have successfully completed their internship) during fourth semester.

Dissertation 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 dissertation 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, plan of completion of their project etc.) to the Dean (PGSR) through the HoD for approval. When the students are planning to do the Dissertation 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 (Scientists or Engineers with a minimum post graduate degree in the related area) and his/her profile with consent
- Name and designation of a faculty member of the College as internal supervisor along with his/her consent
- Letter from the competent authority from the Organization/ Industry granting permission to do the Dissertation
- Details of the proposed work along with the work plan

DLAC will scrutinize the proposal and forward to Dean (PGSR) for approval.
When students are doing dissertation work along with the job in the organization (with R & D

facility) where they are employed, the dissertation work shall be completed in four semesters normally (two semesters of dissertation work along with the job may be considered as equivalent to one semester of dissertation work at the college). Extensions may be granted based on the requests from the student and recommendation of the supervisors such that he/she will

complete the M. Tech programme within four years from the date of admission as per the regulation. Method of assessment and grading of the Dissertation will be the same as in the case of regular students.

The course work in the 3rd semester for such students is to be completed as per the curriculum requirements

(i) MOOC can be completed as per the norms specified in this curriculum.

(ii) Audit course is to be carried out either in the College or by self-learning. However, for self-learning students, all assessments shall be carried out in the college as in the case of regular students.

Marks distribution:

Phase I:	**Total marks: 100**	
	Continuous Internal Evaluation:	100 marks
Phase II:	**Total marks: 200**	
	Continuous Internal Evaluation:	100 marks
	End Semester Examination:	100 marks

Final report of Dissertation/ Research Project:

Students must submit the final report of Dissertation/ Research project on or before the specified deadline. If the report is not submitted on or before the specified deadline, an extension of time up to a maximum of 30 days may be given for the submission of the report with due approval obtained from the HoD.

If a student fails to submit the final report of Dissertation/ Research project on or before the specified deadline/ extended deadline, he/ she is deemed to have failed in Project work and shall re-register for the same in the immediate next semester.

If a student does not appear for the ESE/ fails in the ESE, he/ she is deemed to have failed in Dissertation/ Research Project Phase II and shall have to re-register for the same in the immediate next semester.

(x) TEACHING ASSISTANCESHIP (TA)

All M.Tech students irrespective of their category of admission shall undertake TA duties for a minimum duration as per the curriculum. Being a TA, the student will get an excellent opportunity to improve their expertise in the technical content of the course, enhance communication skills, obtain a hands-on experience in handling the experiments in the laboratory and improve peer interactions.

The possible TA responsibilities include the following: facilitate a discussion section or tutorial for a theory/ course, facilitate to assist the students for a laboratory course, serve as a mentor for students, and act as the course web-master. TAs may be required to attend the instructor's lecture regularly. A TA shall not be employed as a substitute instructor, where the effect is to relieve the instructor of his or her teaching responsibilities. Students who are doing their dissertation work outside the college are not required to do TA work during their second year.

Handling a tutorial session:

(i) Meet the teacher concerned and understand the responsibilities well in advance, attend the lectures of the course for which the student is a tutor, work out the solutions for all the tutorial problems himself/herself, approach the teacher if he/she finds any discrepancy or if he/she needs help in solving the tutorial problems, use reference text books, be innovative and express everything in English only.

(ii) Try to lead the students to the correct solutions by providing appropriate hints rather than solving the entire problem by themselves, encourage questions from the students, lead the group to a discussion based on their questions, plan to ask them some questions, be friendly and open with the students, simultaneously being firm with them.

(iii) Keep track of the progress of each student in the assigned group, give a periodic feedback to the student about his/her progress, issue warnings if the student is consistently under-performing, report to the faculty if TA finds that a particular student is consistently underperforming, pay special attention to slow-learners and be open to the feedback and comments from the students and faculty.

(iv) After the tutorial session TA may be required to grade the tutorials/assignments/tests. Make sure that TA work out the solutions to the questions own their own, and compare it with the answer key, think and work out possible alternate solutions to the same question, understand the marking scheme from the teacher prior to the evaluation.

(v) Consult the teacher and make sure that there is no partiality to any student/ students while grading. They will follow basic ethics in this regard.

Handling a laboratory Session:

(i) Meet the faculty-in-charge a few days in advance of the actual lab class and get the details of the experiment, get clarifications from him/her regarding all aspects of the experiment and the expectations, prepare by reading about the theoretical background of the experiment, know the physical concepts involved in the experiment, go to the laboratory and check out the condition of the equipment/instrumentation, perform the laboratory experiment at least once one or two days before the actual laboratory class, familiarize with safety/ security aspects of the experiment / equipment/laboratory, prepare an instruction sheet for the experiment in consultation with the faculty, and keep sufficient copies ready for distribution to students for their reference.

(ii) Verify condition of the equipment/set up about 30 minutes before the students arrive in the class and be ready with the hand outs, make brief introductory remarks about the experiment, its importance, its relevance to the theory they have studied in the class, ask the students suitable questions to know there level of preparation for the experiment, discuss how to interpret results, ask them comment on the results.

(iii) Correct/evaluate/grade the submitted reports after receiving suitable instructions from the faculty in charge, continue to interact with students if they have any clarifications regarding any aspect of the laboratory session, including of course grading, Carefully observe instrument and human safety in laboratory class, Preparing simple questions for short oral quizzing during explanation of experiments enables

active participation of students, facilitate attention, provides feedback and formative assessment.