VISVESVARAYA TECHNOLOGICAL UNIVERSITY

BELAGAVI



Scheme of Teaching and Examinations (2026)

M.Tech., in Civil Engineering

(Specialization in Environmental Engineering)

Choice-Based Credit System (CBCS) and Outcome-Based Education (OBE)

Specialization in –(Environmental Engineering)

II SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching & Learning Scheme					Examination				Credits
				CI		LI	TW & SL	Total Hours /Semester	Duration in hours	CIE Marks	SEE Marks	Total Marks	
				L	T	P							
1	PCC/ IPCC	1MCEE201	Water Supply, Treatment &Distribution	42	0	28	50	120	03	50	50	100	4
2	PCC	1MCEE202	Wastewater Engineering & Resource, Recovery	42	0	0	48	90	03	50	50	100	3
3	PCC	1MCEE203	Environmental Systems Modelling and Management	42	0	0	48	90	03	50	50	100	3
4	PCC	1MCEE204	Industrial Wastewater Treatment, Prevention and Reuse.	42	0	0	48	90	03	50	50	100	3
5	PEC	1MCEE205X	PEC–III	42	0	0	48	90	03	50	50	100	3
6	PEC	1MCEE206X	PEC–IV	42	0	0	48	90	03	50	50	100	3
7	PCC L	1MCEEL207	Air Quality and Solid Waste Management Laboratory	0	0	28	02	30	03	50	50	100	1
8	PCC	1MCEES208	Minor Project/Skill Development Project	0	0	0	60	60	03	50	50	100	2
									Total	**400**	**400**	**800**	**22**

Professional Elective Courses (PECs)			
PEC-III		**PEC-IV**	
Code	**Title of the Course**	**Code**	**Title of the Course**
1MCEE205A	Environmental Modelling & informatics	1MCEE206A	Air Quality Modelling, Management and Noise Pollution Control
1MCEE205B	Membrane Technologies in Water and wastewater Treatment	1MCEE206B	Geospatial Techniques for Environmental Systems
1MCEE205C	Hydraulics of Environmental Systems	1MCEE206C	AI & ML in Hydrology and Environmental Modelling
1MCEE205D	Environmental Pollution Monitoring & Sensors	1MCEE206D	Urban Green Infrastructure & Nature-Based Solutions

WATER SUPPLY, TREATMENT & DISTRIBUTION			
Course Code	1MCEE201	Scheme	2026
Type of course	**IPCC**	Semester	2
Teaching Hours/Week (L:T:P)	42(3:0:2)	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	120(42:0: 28:50)	SEE Marks	50
Credits	**4**	Total Marks	100
Type of Examination (IPCC):	Theory- CIE +SEE, and Lab-CIE only.	Exam Hours	3

Course outcome (Course Skill Set):

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

1. CO1 (L2-Understand): Explain water sources, water demand estimation, and planning principles for water supply schemes.
2. CO2 (L3-Apply): Apply water treatment concepts including screening, sedimentation, filtration, disinfection, and softening.
3. CO3 (L3-Apply): Design basic components of water transmission and distribution systems, including pipes, pumps, reservoirs, and appurtenances.
4. CO4 (L4-Analyse): Analyze pipe networks, pressure conditions, losses, and water distribution performance.
5. CO5 (L5-Evaluate): Evaluate sustainable and smart water supply strategies for efficient and reliable urban and rural distribution.

Module-1

Introduction to Water Supply Systems:

Importance of water supply, objectives of water supply engineering, sources of water supply, surface water and ground water sources, water demand estimation, per capita demand, factors affecting demand, variations in demand, population forecasting methods, design period, water quality parameters and standards, water supply schemes, basic components of a water supply system.

Linkage: CO1 **Number of Hours: 08**

Module-2

Water Treatment Processes:

Characteristics of water and impurities, need for treatment, water treatment flow diagram, screening, aeration, sedimentation, coagulation and flocculation, filtration, slow sand filter and rapid sand filter, disinfection methods, chlorination and its practice, softening, iron and manganese removal, advanced treatment methods, introduction to membrane processes and fluoridation.

Linkage: CO2 **Number of Hours: 09**

Module-3

Water Treatment Processes:

Intake structures, pumps and pumping systems, selection of pumps, pipe materials, pipe appurtenances, laying of pipelines, analysis of transmission mains, service reservoirs, balancing and combined reservoirs, location and capacity of storage tanks, pressure requirements in distribution systems, water hammer and surge control, protection against leakage and corrosion.

Linkage: CO3 **Number of Hours:09**

Module-4

Water Distribution Systems:

Methods of distribution, gravity, pumping and combined systems, network layouts, dead-end, grid iron, ring and radial systems, hydraulics of pipe flow, head loss in pipes, Hardy Cross method for pipe network analysis, valves and hydrants, metering, household connections, leak detection, pressure management, operation and maintenance of distribution systems.

Linkage: CO4 **Number of Hours: 08**

Module-5

Modern Water Supply Management:

Water conservation and demand management, rainwater harvesting and reuse, smart water distribution systems, SCADA and automation in water supply, non-revenue water reduction, GIS and digital tools in distribution planning, sustainable urban water management, rural water supply schemes, water safety planning, case studies on efficient water supply management.

Linkage: CO5 **Number of Hours: 08**

PRACTICAL COMPONENTS OF IPCC

LIST OF EXPERIMENTS (LI-28Hrs)

1. Determination of pH, acidity and alkalinity of water – using pH meter and titration (aligns with IS 10500 pH 6.5–8.5 and alkalinity limits).
2. Measurement of turbidity by nephelometer – comparison with BIS turbidity limits (1 NTU acceptable, 5 NTU permissible).
3. Determination of total dissolved solids (TDS) and electrical conductivity – using gravimetric/evaporation method and conductivity meter (TDS 500–2000 mg/L as per IS 10500).
4. Determination of total, calcium and magnesium hardness – EDTA titration, linked to BIS hardness limits (200–600 mg/L as $CaCO_3$).
5. Determination of chlorides in water – argentometric titration, compared with BIS limits (250–1000 mg/L).
6. Determination of sulphates and nitrates – spectrophotometric methods, checked against BIS limits (SO_4 200–400 mg/L, NO_3 45 mg/L).
7. Determination of dissolved oxygen (DO) – Winkler's iodometric method; foundation for BOD and treatment process design.
8. Determination of 5-day BOD of treated/untreated water – incubator method at 20 °C, checking organic pollution relevant to supply from surface sources.
9. Jar test for determination of optimum alum (or other coagulant) dose – studying coagulation–flocculation and turbidity removal for conventional treatment plants.
10. Determination of percentage of available chlorine in bleaching powder – iodometric titration, to design disinfection dosage.
11. Determination of residual chlorine in treated water – starch–iodine method or DPD method, ensuring residual free chlorine 0.2–0.5 mg/L as per standards.
12. Breakpoint chlorination and chlorine demand study – preparation of chlorine–residual curve to identify breakpoint dosage for safe disinfection

Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):

Text books:

1. S. K. Garg, Environmental Engineering, Vol. I: Water Supply Engineering, Khanna Publishers, 2010 edition.
2. B. C. Punmia, Ashok Jain, Arun Jain, Environmental Engineering I: Water Supply Engineering, Laxmi Publications, 2010 edition.
3. E. W. Steel, Water Supply Engineering, McGraw-Hill
4. G. S. Birdie and J. S. Birdie, Water Supply and Sanitary Engineering, Dhanpat Rai Publications, standard edition.
5. Howard S. Peavy, Donald R. Rowe, George Tchobanoglous, Environmental Engineering, McGraw-Hill International Edition, 2000 edition

Reference Books/Manuals:

1. Mark J. Hammer, Water and Wastewater Technology, John Wiley & Sons, 2008 edition.
2. K. N. Duggal, Elements of Public Health Engineering, S. Chand / Indian academic publisher editions.
3. S. R. Kshirsagar, Water Supply Engineering, standard Indian reference text used in civil engineering.
4. Textbook of Water Supply and Sanitary Engineering, CBS Publishers & Distributors, 2017 edition.
5. CPHEEO, Manual on Water Supply and Treatment, Government of India / MoUD, latest revised manual available through Jal Shakti / MoHUA portals.
6. CPHEEO Laboratory Tests and Procedures.
7. NEERI Guidance Manual for Drinking Water Quality Monitoring and Assessment.
8. **IS 10500** — Drinking water specification; use this for all quality-parameter experiments such as pH, turbidity, TDS, hardness, chloride, fluoride, iron, and bacteriological quality.
9. **IS 1172:1993** — Code of basic requirements for water supply, drainage and sanitation; useful as a general reference for water supply basics.
10. **IS 2065:1983** — Code of practice for water supply in buildings; relevant for distribution and building-level supply systems.
11. **IS 17482:2020** — Drinking water supply management system requirements for piped drinking water supply service; useful for utility-level treatment and distribution quality management.

Web links and Video Lectures (e-Resources):

1. NPTEL – Water Supply Engineering: an integrated 12-week course covering demand estimation, intake works, treatment, distribution networks, NRW, automation, SCADA, and water economics.
2. Jal Shakti / MoHUA CPHEEO manual page: official access point for the Manual on Water Supply and Treatment Systems.
3. Public Health Engineering Department manuals page: useful for engineering planning, design, implementation, O&M, and management manuals.
4. India Water Portal: explanatory notes and discussion on CPHEEO manual and drinking water engineering practice.
5. NPTEL Video Course: Water Supply Engineering — best structured academic resource for UG students; suitable for lectures, assignments, and design understanding.
6. YouTube academic channels on water treatment plant design, Hardy Cross method, pipe network analysis, and chlorination.
7. Institutional lecture series from IITs/IISc on environmental engineering topics, especially water supply and water treatment.

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. Concept-Based Interactive Lectures.
2. Case Study-Based Learning.
3. Problem-Based Learning (PBL).
4. Laboratory Experiments & Hands-on Training.
5. Simulation and Software-Based Learning.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.

- A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject /course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

(i)Theory component

The CIE marks of 25 shall be earmarked for two tests.

The first test shall be conducted after completing two modules of the syllabus and the second one after completing the rest three modules.

Each test shall be conducted for 25 marks. The average of the two tests scaled down to 25 marks shall constitute the test marks for a maximum of 25 marks.

(ii) Laboratory component

Out of 25 marks, 15 marks shall be assigned for assessment of regular laboratory classwork as per the rubrics listed in Table - ICs/IPCCs1.

The remaining 10 marks shall be based on the practical test conducted by two Internal examiners appointed by the HoD. The allotment of marks shall be as per the rubrics defined for the practical test as indicated in the Table – ICs/IPCCs 1.

To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 13 marks out of 25 in the CIE theory component, and at least 12 marks in the CIE Practical component.

Table – ICs/IPCCs 1 Distribution of marks corresponding to laboratory component

Component	Description	Marks
Allotment of marks for regular classwork		
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	5 marks
Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission.	10 marks
	Subtotal	**15**
Allotment of marks for CIE practical test		
Laboratory Test / Experiment Performance	Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment.	5 marks
Viva-Voce	Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions.	5 marks
	Subtotal	**10**
	Total	**25**

Term work and Self Learning:

Students' activities for TW/SL under NCrF: As per National credit framework (NCrF) students must spend 120 hours of study for 4 credit courses, which include Course instructions (CI-70 hour) and Teamwork/Self learning (TW/SL-50 hours). Hence, students must complete minimum of two activities as part of NCrF. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The course coordinator can also design learning activities based on course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**Activity TW-A: Treatment process design and lab testing**	25

	Teams of 2–3 students perform jar test experiments to determine optimum coagulant dose, design flocculation and sedimentation units, perform pilot-scale filter run (bench), analyze raw and treated water quality, and prepare a detailed technical report and presentation. Linkage: CO2, CO3.	
2	**Activity TW-B: Distribution network hydraulic design and simulation (24 hours)** Individual/team designs a distribution network for a small town or campus: demand estimation, pipe sizing, storage sizing, pump selection, hydraulic simulation using EPANET, scenario analysis (fire demand, pump failure), and prepares report and presentation. Linkage: CO4.	25
3	**Field visit report:** Independently visit a local WTP or pumping station, collect operational data, interview O&M staff, and prepare an analytical report (with suggestions for improvements). Linkage: CO3, CO4.	25
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	Complete an NPTEL / Coursera course module on water treatment/distribution, submit a 3–5-page critique applying concepts to local case study, and prepare a 10-minute video or presentation. Linkage: CO1, CO2	25
2	Self-learn EPANET or QGIS through tutorials; develop a small EPANET model or GIS map of a distribution network and submit files + report. Linkage: CO4.	25

Sample Rubrics -Term Work

Criterion	**5**	**4**	**3**	**2**	**1**
Planning and execution	Work is well planned, systematic, and completed on time with clear methodology.	Good planning and timely execution with minor gaps.	Adequate planning and mostly completed work.	Limited planning; execution has noticeable issues.	Poor planning and incomplete execution.
Technical accuracy	All calculations, analysis, and design steps are correct and justified.	Mostly correct with minor errors.	Acceptable with some errors.	Several errors affecting clarity.	Major technical errors or incorrect work.
Use of tools / software	Excellent use of lab tools, drawings, or software with proper outputs.	Good use with minor limitations.	Basic use of tools/software.	Limited or partially correct use.	No meaningful use of required tools.
Report documentation	Well-structured, complete, neat, and properly referenced.	Clear and complete with minor formatting issues.	Satisfactory documentation.	Incomplete or poorly organized.	Very poor or missing documentation.
Presentation and interpretation	Excellent oral presentation and strong interpretation of results.	Good presentation and interpretation.	Adequate presentation.	Weak explanation and interpretation.	Unable to present or interpret findings.

Self-Learning Rubric:

Criterion	5	4	3	2	1
Independent learning effort	Extensive self-study with strong initiative and depth.	Good evidence of independent effort.	Adequate effort shown.	Limited independent effort.	Minimal effort.
Application of concepts	Concepts are applied effectively to real problems or case studies.	Good application with minor gaps.	Basic application shown.	Weak application of concepts.	No meaningful application.
Quality of submission	Submission is well-organized, clear, and complete.	Good quality with minor issues.	Acceptable quality.	Poorly organized or incomplete.	Very poor or missing submission.
Innovation and initiative	Demonstrates originality, extra exploration, and strong initiative.	Some innovative effort is evident.	Limited creativity.	Very little initiative.	No initiative shown.

Suggested rubrics for Practical continuous assessment:

Performance Indicators	**Excellent**	**Very Good**	**Good**	**Satisfactory**
Fundamental Knowledge (4) (PO1)	The student has well depth knowledge of the topics related to the course (4)	Student has good knowledge of some of the topics related to course (3)	Student is capable of narrating the answer but not capable to show in depth knowledge (2)	Student has not understood the concepts clearly (1)
Design Of Experiment (5) (PO2 & PO3)	Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable design with proper reason (5)	Student is capable of discussing few designs for his/her problem statement but not capable of selecting best (4)	Student is capable of discussing single design with its merits and de-merits (3)	Student is capable of explaining the design (1-2)
Implementation (8) (PO3 & PO8)	Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8)	Student is capable of implementing the design with best suitable algorithm and should be capable of explaining it (5-6)	Student is capable of implementing the design with proper explanation. (3-4)	Student is capable of implementing the design. (1-2)
Result &Analysis (5) (PO4)	Student is able to run the program on various cases and compare the result with proper analysis. (5)	Student will be able to run the program for all the cases. (4)	Student will be able to run the code for few cases and analyze the output (3)	Student will be able to run the program but not able to analyze the output (1-2)

Demonstration (8) (PO9)	The lab record is well-organized, with clear sections (e.g., Introduction, Method, Results, Conclusion). Transitions between sections are smooth. (7-8)	The lab record is organized, with clear sections, but some sections are not well-defined. (5-6)	The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4)	The lab record is poorly organized, with missing or unclear sections. (1-2)

Note: Can add Engineering & IT tool usage based on the nature of the course

WASTEWATER ENGINEERING AND RESOURCE RECOVERY		Semester	2
Course Code	1MCEE202	CIE Marks	50
Teaching Hours/Week (CI:LI:TW: SL)	42 (3:0:0)	SEE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	90 (42:0: 28:50)	Total Marks	100
Credits	3		
Examination type (SEE)	**Theory**	Examination	03

Course outcome (Course Skill Set):

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

1. CO1 (L2 – Understand): Explain types, sources and characteristics of wastewater, relevant discharge/reuse standards and the philosophy of wastewater treatment and recycling.
2. CO2 (L3 – Apply): Apply mass balance, reaction kinetics and process principles to configure and size conventional preliminary, primary and secondary treatment units.
3. CO3 (L4 – Analyse): Analyse performance and limitations of advanced treatment, nutrient removal and sludge management processes for different application scenarios.
4. CO4 (L5 – Evaluate): Evaluate and compare technologies and process trains for recovery of nutrients, organics, energy, metals and reclaimed water from wastewater.
5. CO5 (L6 – Create): Develop integrated wastewater treatment and resource recovery schemes, including water reuse and energy recovery, and justify them using environmental and techno-economic criteria

Module-1

Wastewater and resource recovery fundamentals:

- Overview of wastewater: types and sources (municipal, industrial, agricultural), point and non-point sources, generation and quantity estimation.iitr.ac+1
- Wastewater characteristics: physical, chemical and biological parameters (BOD, COD, TOC, solids, nutrients, metals, priority and emerging pollutants), population equivalent, regulatory standards for discharge and reuse (Indian and international overview).
- Philosophy of wastewater treatment: pollution control vs circular economy; wastewater as a source of water, nutrients, energy and materials; drivers for reuse and resource recovery (water scarcity, climate change, SDGs)

Linkage: CO1 **Number of hours: 08**

Module-2

Conventional treatment processes:

- Treatment trains and process selection: objectives of preliminary, primary and secondary treatment; process flow diagrams of typical municipal WWTPs.
- Preliminary and primary treatment: screening, grit removal, equalisation, primary sedimentation; sedimentation theory and design considerations.
- Secondary biological treatment: microbial ecology and growth kinetics; suspended and attached growth systems; activated sludge process, trickling filters, rotating biological contactors, aerated lagoons and stabilization ponds – process description, key design parameters and performance indicators.
- Overview of natural treatment systems (waste stabilization ponds, constructed wetlands, land treatment) as low-energy options relevant to resource recovery.

Linkage: CO1, CO2 **Number of hours: 09**

Module-3

Advanced treatment, nutrient removal and sludge management:

- Biological nutrient removal: nitrogen removal (nitrification, denitrification, anammox), phosphorus removal (EBPR, chemical precipitation), combined N and P removal processes.
- Advanced physical–chemical processes: adsorption, ion exchange, advanced oxidation processes, gas stripping, disinfection (UV, ozone, chlorine) for polishing and reuse.
- Membrane processes: microfiltration, ultrafiltration, nanofiltration, reverse osmosis and membrane bioreactors (MBR) for high-quality effluent and reuse.
- Sludge handling and processing: sludge characteristics, thickening, stabilization (aerobic and anaerobic digestion), conditioning, dewatering, drying and disposal/reuse options (compost, bio-solids)

Linkage: CO2, CO3 **Number of hours: 09**

Module-4

Technologies for resource recovery from wastewater:

- Concepts for wastewater mining and circular economy: partition–release–recovery concept, re-engineering conventional WWTPs into resource recovery facilities.
- Nutrient recovery: phosphorus recovery (struvite precipitation, crystallization, adsorption–desorption), nitrogen recovery (ammonia stripping, ion exchange, membrane-based approaches), product quality and use as fertilizers.
- Organics and energy recovery: anaerobic digestion of sludge and high-strength wastes for biogas; combined heat and power (CHP); bio-electrochemical systems (microbial fuel cells and microbial electrolysis cells) for energy recovery.
- Metals and other resource recovery: recovery of metals and other valuables from industrial wastewaters; examples of integrated industrial wastewater resource recovery systems.

Linkage: CO3, CO4 **Number of hours: 08**

Module-5

Water reuse and integrated resource recovery systems

- Wastewater recycling and reuse: types and stages of recycling; centralised vs decentralised systems; designated reuse criteria for agricultural, industrial, groundwater recharge and non-potable urban uses.
- Process integration and technology selection: assembling treatment–recovery trains to meet reuse specifications; choice modelling, decision-making tools and multi-criteria assessment (technical, economic, environmental and social).
- Case studies: Indian and global examples of wastewater treatment plants acting as "resource factories" – nutrient recovery, water reuse, biogas-based energy, algal systems.
- Policy, governance and stakeholder aspects: regulatory frameworks, business models, social acceptance and risk communication for resource-recovery-based wastewater management.

Linkage: CO4, CO5 **Number of hours: 08**

Suggested Learning Resource:

Text Books:

1. Tchobanoglous, G., Stensel, H.D. et al., "Wastewater Engineering: Treatment and Resource Recovery", 5th ed., McGraw Hill Education.
2. Metcalf & Eddy – Wastewater Engineering: Treatment and Resource Recovery (5th ed., McGraw-Hill)
3. T. A. Larsen, K. M. Udert, & J. Lienert – Source Separation and Decentralization for Wastewater Management (IWA)
4. Water Environment Federation (WEF) – Nutrient Recovery
5. Ilje Pikaar, Jeremy Guest, Ramon Ganigué (eds.), "Resource Recovery from Water", IWA Publishing.

Reference Books:

1. Relevant CPHEEO / CPCB / BIS manuals and guidelines on sewage treatment and water reuse (latest

editions).
2. TU Delft OCW, "Wastewater Treatment" – lecture notes and modules (online open course).
3. HRE-902 "Wastewater Resource Recovery", IIT Roorkee – course syllabus and notes (for Indian context examples).

Web links and Video Lectures (e-Resources)

1. VTU Online course: Wastewater Treatment and Recycling (course brochure and materials).
2. TU Delft OCW – Wastewater Treatment (videos, lecture notes and problems).
3. NPTEL MOOCs on Wastewater Treatment, Water and Wastewater Engineering, Biological Waste Treatment (IITs).
4. International Water Association (IWA) resources on resource recovery and circular water systems.

10

Assessment Structure (both CIE and SEE):

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt in addition to chalk and talk to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes. Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**The group mini-project is to design an integrated wastewater treatment plant for a realistic 1 MLD municipal, campus, town, or industrialscenario.** The team should characterize the wastewater and define suitable reuse or discharge objectives. They should propose a complete treatment and resource recovery train, including conventional, advanced, and recovery units. Finally, the group should do preliminary sizing, estimate recovered	24

	products, and recommend the best option using environmental and economic criteria.	
2	**Case-study seminar on global/Indian resource-recovery plants:** Groups identify and study one real facility (India or abroad) where WWTP has been upgraded or designed as a "resource recovery plant" (e.g., nutrient recovery, biogas CHP, advanced reuse). They prepare a 10–12 slide seminar and a 2–3 page summary sheet.	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	Students independently complete selected NPTEL / TU Delft OCW modules on wastewater resource recovery or water reuse, and submit a 3–4 page reflective report highlighting key learnings and potential applications in Indian context	24
2	**Technical brief on a specific recovery technology:** Each student prepares a 2-page technical brief on one assigned technology (e.g., struvite precipitation, ammonia stripping, anaerobic digestion, MFC, MBR-based reuse, algal treatment) summarizing working principle, typical applications, advantages/limitations and one case study	24

Rubric for Group Mini-Project: Integrated WWTP with Resource Recovery:

Criterion	Excellent (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
Problem definition and wastewater characterization	Clearly defines the problem, assumptions, wastewater characteristics, and reuse/discharge objectives.	Defines the problem and major characteristics with minor gaps.	Basic problem statement with limited characterization.	Poorly defined problem or incomplete characterization.
Process selection and treatment train	Proposes a logically connected conventional, advanced, and resource recovery train.	Proposes a suitable train with minor missing links.	Proposes a partially correct train with limited justification.	Inappropriate or incomplete treatment train.
Preliminary sizing and recovery estimation	Correctly sizes key units and reasonably estimates water, biogas, and nutrient recovery.	Mostly correct sizing with minor errors in recovery estimates.	Basic sizing attempted with several gaps or errors.	Little or no valid sizing or recovery estimation.
Environmental and economic evaluation	Compares alternatives clearly using relevant environmental and economic criteria.	Compares options with some justification.	Limited comparison with weak justification.	No meaningful evaluation of alternatives.
Presentation and teamwork	Well-organized report/presentation with effective teamwork and clear communication.	Good presentation with minor issues in organization or teamwork.	Acceptable presentation but uneven contribution or clarity.	Poor presentation, weak teamwork, or unclear communication.

ENVIRONMENTAL SYSTEMS MODELLING AND MANAGEMENT			
Course Code	**1MCEE203**	Scheme	2026
Type of Course	**PCC**	Semester	2
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per semester L /T/P/SL&TW:	90(42:0:0:48)	SEE Marks	50
Credits	**3**	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course outcome (Course Skill Set)

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

1. CO1: Explain modelling concepts, transport processes, and water quality parameters.
2. CO2: Apply steady-state and transient models to surface and groundwater systems.
3. CO3: Analyse pollutant fate, oxygen sag, mixing, and contaminant migration.
4. CO4: Evaluate numerical model outputs, calibration results, and control strategies.
5. CO5: Design a simple modelling solution for a selected water quality problem.

Module-1

Fundamentals and Transport Processes:

Modelling – introduction, objectives, applications in environmental management. Concept of system boundaries, assumptions, state variables, forcing functions, and response variables. Physical phenomena – advection, diffusion, dispersion, Fick's laws of diffusion, convective-diffusion equations for turbulent and shear flow regimes. One-dimensional transport equation, steady and unsteady transport, interpretation of boundary conditions.

Number of Hours: 08Hrs

Module-2

Steady-State Surface Water Quality Modeling:

Steady-state water quality modeling – models for conservative and non-conservative substances. 1-D oxygen balance models – Streeter-Phelps equation, deoxygenation and re-aeration concepts. Critical point method, oxygen sag curve, time-distance relationships. Calibration and verification of DO simulation models. Dissolved oxygen models for lakes under completely mixed and stratified conditions**.** Numerical exercises.

Number of Hours: 10Hrs

Module-3

Mixing Zones and Stream Analysis:

Mixing zones in rivers – types of outfalls and mixing regimes. Stream tube concept, complete and incomplete mixing, steady-state 2-D analysis. Parameter estimation – lateral mixing coefficient, critical point method, dye study interpretation. Case studies on wastewater discharge into rivers and mixing zone assessment. Numerical exercises. Numerical exercises.

Number of Hours:08 Hrs

Module-4

Data Collection, Estuaries, and Ocean Outfalls:

Data collection and analysis – specialized water quality surveys, sampling frequency, field measurements, and laboratory analysis. Estimation of decay and re-aeration rates from observed data.

Estuaries – salinity distribution, tidal mixing, and mathematical analysis of pollutant dispersion in estuaries.

Ocean disposal of wastewater – siting and design of outfalls, environmental constraints, dilution and dispersion concepts. Numerical exercises.

Number of Hours:08Hrs

Module-5

Ground water quality modeling concepts - formulation of 1-D model with decay and retardation for instantaneous sources, plume delineation studies. Migration of pollutants through soil. Salient features of environmental simulation models / software. Numerical exercises.

Number of Hours:08 Hrs

Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):

Text books:

1. Thomann R.V., and Mueller J.A., (1987), "Principles of Water Quality Management andControl", Harper & Row Publications.
2. Schnoor J.L., (1996) "Environmental Modelling – Fate and Transport of Pollutants in Water, Air and Soil", John Wiley and Sons.
3. Chapra, S. C., Surface Water-Quality Modeling, McGraw-Hill, 1st Edition, 1997.
4. Bear, J., Hydraulics of Groundwater, McGraw-Hill International Book Company, 1st Edition, 1979.
5. Freeze, R. A. and Cherry, J. A., Groundwater, Prentice-Hall, 1st Edition, 1979.

Reference books / Manuals:

1. Rich L.G., "Environmental Systems Engineering ", McGraw Hill.
2. Thomann R.V., (1980), "Systems Approach to Water Quality Management", McGrawHill.
3. Lee C.C., and Lin S.D., (1999), "Handbook of Environmental Engineering Calculations", McGraw Hill, New York.
4. Metcalf and Eddy Inc., (1995), "Wastewater Engineering - Treatment and Reuse", 3RDEdition, Tata McGraw Hill Publishing Co. Ltd., New Delhi.

Web links and Video Lectures (e-Resources):

1. **US EPA – Surface Water Quality Modeling**: overview, training, and modeling resources for water-quality management.
2. **US EPA – Surface Water Quality Modeling Tools**: includes HAWQS, BASINS, WASP, QUAL2K, AQUATOX, and related tools.
3. **INOWAS Tutorials**: step-by-step groundwater modeling tutorials, including steady-state and transient flow models and scenario analysis.
4. **FREEWAT**: open-source GIS-integrated platform for simulation of water quantity and quality in surface water and groundwater systems.
5. **USACE HEC Water Quality**: water-quality capabilities within HEC-RAS, HEC-ResSim, and HEC-HMS, useful for integrated river and reservoir modeling.

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt in addition to chalk and talk to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes. Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of **40%** of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** shall be conducted. Each test shall be conducted for a maximum of **25 marks**. The average of the two test marks shall be the marks secured by a student in IA.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25** marks.

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	Solve numerical problems on advection, diffusion, dispersion, and Fick's law.	24
2	Estimate mixing zone concentration and lateral mixing coefficient for a river outfall case study.	24
3	Prepare a groundwater contaminant plume calculation for an instantaneous source with decay and retardation.	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	Study online resources or MOOCs on water quality modeling and submit a summary report.	24
2	Review research papers on surface water and groundwater contaminant transport and prepare a comparative note.	24
3	Explore open water quality datasets from CPCB, CGWB, USGS, or WHO and prepare a data interpretation note.	24

Rubrics for TW activities:

Criteria	Excellent (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
Numerical Accuracy	All calculations are correct with proper units and interpretation.	Minor calculation errors, overall correct method.	Partly correct calculations with limited interpretation.	Major errors or incomplete solution.
Conceptual Understanding	Shows strong understanding of model principles and water quality processes.	Good understanding with minor gaps.	Basic understanding of concepts.	Limited understanding.

Criteria	Excellent (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
Problem Solving Approach	Logical, systematic, and complete solution process.	Mostly systematic with small omissions.	Partial solution method.	Poor or unclear problem-solving effort.
Presentation and Clarity	Neat, well-organized, and easy to follow.	Good presentation with minor issues.	Average presentation quality.	Unclear or poorly organized.
Team Participation	All members contribute actively and evenly.	Most members contribute well.	Uneven participation.	Minimal participation.
Report Quality	Well-structured, complete, and technically sound.	Good report with minor shortcomings.	Adequate documentation.	Poor report quality.

INDUSTRIAL WASTEWATER TREATMENT, PREVENTION AND REUSE			
Course Code	**1MCEE204**	Scheme	2026
Type of Course	**PCC**	Semester	2
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per semester L /T/P/SL&TW:	90(42:0:0:48)	SEE Marks	50
Credits	**3**	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course outcome (Course Skill Set)

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

1. CO1: Explain the characteristics, sources, and environmental impacts of industrial wastewater.
2. CO2: Identify pollution prevention and water minimization strategies in industrial processes.
3. CO3: Apply suitable treatment methods for industrial wastewater based on wastewater quality and industry type.
4. CO4: Evaluate advanced treatment, reuse, and zero liquid discharge concepts for industrial applications.
5. CO5: Design integrated wastewater management strategies incorporating treatment, reuse, and resource recovery.
6. CO6: Assess regulatory, economic, and sustainability aspects of industrial wastewater management.

Module-1

Introduction to Industrial Wastewater:

- Sources, generation, and classification of industrial wastewater.
- Characteristics of industrial effluents: physical, chemical, and biological parameters.
- Pollutants of concern: organics, inorganics, toxic compounds, heavy metals, oil and grease, nutrients, and color.
- Environmental and public health impacts of industrial wastewater discharge.
- Sampling, characterization, and interpretation of wastewater quality data.

Linked COs: CO1 **Number of Hours: 08 hrs**

Module-2

Pollution Prevention and Water Minimization:

- Cleaner production principles and pollution prevention hierarchy.
- Process modification, raw material substitution, good housekeeping, segregation of streams, and leak control.
- Water audits, water balance, and benchmarking in industries.
- Recycling, reuse within plant, and conservation practices.
- Concept of industrial symbiosis and resource efficiency.

Linked COs: CO2 **Number of Hours:** 08 hrs

Module-3

Pretreatment of Industrial Wastewater:

Volume reduction, Strength reduction, Neutralization, Equalization and Proportion, Removal of inorganic dissolved solids.

Primary and Secondary Treatment:

- Preliminary treatment: screening, equalization, oil and grease removal, neutralization.
- Primary treatment: sedimentation, coagulation, flocculation, flotation, and chemical precipitation.
- Biological treatment: activated sludge process, trickling filters, oxidation ponds, aerated lagoons, and moving bed biofilm reactors.
- Treatment of high-strength and biodegradable industrial effluents.
- Sludge generation, handling, and disposal issues.

Linked COs: CO3 **Number of Hours: 09 hrs**

Module-4

Advanced Treatment and Reuse:

- Tertiary treatment methods: filtration, adsorption, ion exchange, membrane processes, and disinfection.
- Advanced oxidation processes, nutrient removal, and color removal.
- Treatment of recalcitrant, toxic, and non-biodegradable industrial wastewaters.
- Water reuse options in process, utility, landscaping, cooling towers, and washing applications.
- Zero liquid discharge concept, brine management, and resource recovery.

Linked COs: CO4, CO5 **Number of Hours: 09 hrs**

Module-5

Industry-Specific Management and Sustainability:

- Wastewater management in textile, tannery, pharmaceutical, food processing, pulp and paper, electroplating, and dairy industries.
- Treatment train selection based on industry type and effluent characteristics.
- Environmental regulations, standards, consent requirements, and compliance aspects.
- Economic evaluation, lifecycle considerations, and sustainability in wastewater reuse.
- Case studies on industrial water recycling and reuse systems.

Linked COs: CO5, CO6 **Number of Hours: 08 hrs**

Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):

Text books:

1. Metcalf & Eddy, Inc., AECOM, Wastewater Engineering: Treatment and Resource Recovery, 5th Edition, McGraw-Hill Education, New York, 2014.
2. Nemerow, N. L., Industrial Waste Treatment: Contemporary Practice and Vision for the Future, 1st Edition, Butterworth-Heinemann, Burlington, 2007.
3. Eckenfelder, W. W., Industrial Water Pollution Control, 3rd Edition, McGraw-Hill International Editions, New York, 2000.
4. Perry L. McCarty, Industrial Wastewater Treatment, McGraw-Hill.
5. Arceivala, Wastewater Treatment for Pollution Control, McGraw-Hill Education.
6. M. N. Rao and H. V. N. Rao, Wastewater Treatment Technologies, New Age International Publishers.

Reference books / Manuals:

1. C. N. Sawyer, P. L. McCarty, and G. F. Parkin, *Chemistry for Environmental Engineering and Science*, McGraw-Hill Education.
2. Syed R. Qasim, *Wastewater Treatment Plants: Planning, Design, and Operation*, CRC Press.
3. Standard manuals on industrial effluent treatment and zero liquid discharge systems, published by CPCB/SPCB and technical agencies.
4. Relevant CPCB/SPCB guidelines and technical reports on industrial wastewater management.

Web links and Video Lectures (e-Resources):

1. NPTEL/SWAYAM courses on wastewater treatment and environmental engineering.
2. CPCB and SPCB standards, manuals, and online resources.
3. Technical case studies from industries implementing water reuse and ZLD systems.
4. Research articles and policy documents on industrial water management. https://ciet.ncert.gov.in/initiative/moocs-on-swayam?utm
5. UNESCO Water Resources Learning Materials

https://www.unesco.org/en/articles/materials-integrated-water-resources-management-study-course?utm
https://www.unesco.org/en/articles/towards-water-cloud-learning-resources-inclusive-sustainable-futures?utm

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. Industrial ETP case studies
2. Wastewater reuse system design exercises
3. Simulation of treatment processes
4. Industry expert lectures / industrial visits
5. Smart monitoring demonstrations

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of **40%** of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** shall be conducted. Each test shall be conducted for a maximum of **25 marks**. The average of the two test marks shall be the marks secured by a student in IA.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25** marks.

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	Industrial wastewater characterization and treatment train identification for a selected industry.	24
2	Water audit and minimization proposal for an industry.	24
3	Reuse and ZLD concept note for a selected industrial sector.	24

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	Review one CPCB/SPCB guideline on industrial effluent management and prepare a reflective note.	24

2	Study a case of industrial water reuse and summarize the treatment and reuse strategy.	24
3	Watch a MOOC/video module on membrane treatment or ZLD and submit a learning note.	24

Sample Rubric for TW Activities:

Criteria	**4 - Excellent**	**3 - Good**	**2 - Satisfactory**	**1 - Needs Improvement**
Problem understanding	Clear problem framing with strong justification.	Mostly clear with minor gaps.	Basic attempt with limited clarity.	Poorly defined problem.
Data and method	Appropriate data and sound methodology.	Mostly appropriate with minor issues.	Limited data or partial method.	Inadequate or incorrect method.
Analysis	Robust interpretation and valid results.	Generally sound with minor errors.	Partial analysis with gaps.	Weak or incorrect analysis.
Recommendations	Strong, feasible, and context-specific.	Relevant with minor limitations.	Generic recommendations.	Incomplete or unrealistic.
Presentation	Well organized and professional.	Good organization with minor issues.	Acceptable but uneven.	Poorly presented.

ENVIRONMENTAL MODELLING & INFORMATICS			
Course Code	**1MCEE205A**	Scheme	2026
Type of Course	**PEC**	Semester	II
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per semester L /T/P/SL&TW:	90(42:0:0:48)	SEE Marks	50
Credits	**3**	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

Course outcome (Course Skill Set)

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

1. CO1: Explain the concepts, scope, and relevance of environmental modelling and informatics in environmental engineering practice.
2. CO2: Apply mathematical, statistical, and data-driven techniques to represent environmental systems and processes.
3. CO3: Develop and interpret models for air, water, soil, and waste-related environmental phenomena.
4. CO4: Use informatics tools, sensors, GIS, remote sensing, and databases for environmental monitoring and analysis.
5. CO5: Evaluate model outputs, uncertainty, validation methods, and decision-support implications in environmental management.
6. CO6: Integrate digital tools, simulation platforms, and data visualization for sustainable environmental planning and reporting

Module-1

Introduction to environmental modelling and informatics:

Environmental systems, model concepts, types of models, deterministic and stochastic approaches, empirical and mechanistic models, and the role of informatics in environmental engineering. System boundaries, scales, model inputs and outputs, and fundamentals of environmental data handling. Introduction to digital environmental management and decision support systems.

Linked COs: CO1, CO6. **Number of Hours: 08**

Module-2

Data, statistics, and computational foundations:

Environmental data types, data quality, preprocessing, missing data, outliers, and uncertainty. Descriptive statistics, correlation, regression, time-series basics, and introduction to numerical methods used in environmental modelling. Data acquisition from field instruments, sensors, remote platforms, and digital archives.

Linked COs: CO2, CO4, CO6. **Number of Hours:** 09

Module-3

Modelling of air and water systems:

Modelling of air pollution dispersion, meteorological influence, emission characterization, and source-receptor relationships. Surface water quality modelling, stream transport, oxygen sag concept, pollutant decay, and basic watershed response models. Introduction to groundwater contamination and contaminant transport concepts.

Linked COs: CO2, CO3, CO5. **Number of Hours: 09**

Module-4

Environmental informatics tools and spatial analysis:

GIS for environmental applications, remote sensing basics, spatial data structures, environmental layers, and map-based analysis. Use of databases, dashboards, sensors, IoT-enabled environmental monitoring, and cloud-based data repositories. Introduction to environmental informatics workflows for mapping pollution hotspots, vulnerability zones, and resource-use patterns.

Linked COs: CO4, CO6. **Number of Hours:08**

Module-5

Model calibration, validation, and decision support:
Model calibration, sensitivity analysis, uncertainty assessment, and validation methods. Scenario analysis, forecasting, and interpretation of model outputs for planning and management. Decision-support systems for environmental management, sustainability indicators, reporting frameworks, and communication of results through tables, charts, and dashboards**.**

Linked COs: CO3, CO5, CO6. **Number of Hours:08**

Suggested Learning Resources

Textbooks:

1. C. S. Rao, Environmental Pollution Control Engineering, New Age International, latest edition.
2. Gilbert M. Masters and Wendell P. Ela, Introduction to Environmental Engineering and Science, latest edition.
3. S. K. Garg, Environmental Engineering, Khanna Publishers, latest edition.
4. Daniel A. Vallero, Environmental Biotechnology: A Biosystems Approach, latest edition, where relevant.
5. R. S. Ramalho, Introduction to Wastewater Treatment Processes, latest edition, where relevant.
6. John M. Barry or similar standard text on environmental modelling, latest edition, as applicable.

Reference Books:

1. EPA / equivalent agency manuals on environmental modelling and monitoring.
2. BIS and CPCB / SPCB guidance documents relevant to environmental data and standards.
3. GIS and remote sensing handbooks for environmental applications.
4. Model documentation and user manuals of standard environmental software tools.
5. Recent review papers and technical reports on environmental informatics, climate, and monitoring systems.

Web Links and e-Resources:

1. NPTEL / SWAYAM courses on environmental modelling, GIS, remote sensing, and environmental informatics.
2. Open-source tools and tutorials for spatial analysis, modelling, and visualization.
3. Government and agency portals for environmental data, monitoring, and standards.

Teaching-Learning Process (Innovative Delivery Methods):

- Flipped classroom.
- Problem-based learning.
- Case-based teaching.
- Simulation and software-based exercises.
- ICT-enabled teaching.
- Field data interpretation and mini-projects.

Suggested strategies:

- Use real environmental datasets for hands-on interpretation.
- Compare observed data with model predictions through case studies.
- Conduct simple calibration and validation exercises.
- Use GIS layers, sensor data, and dashboards for applied learning.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.
In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks.

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	Environmental data case study: Analyse an industrial, urban, or watershed dataset and identify pollution trends, drivers, and mitigation options	24
2	Model development exercise: Prepare a simple environmental model for air quality, water quality, or waste generation using spreadsheet/software tools.	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	MOOC modules on environmental modelling, GIS, and environmental monitoring	24
2	Preparation of a digital portfolio containing datasets, charts, maps, and interpretation notes.	24

Rubric for TW Activities:

Criteria	4 – Excellent	3 – Good	2 – Fair	1 – Needs Improvement
Problem understanding	Clearly defines the environmental issue with strong reasoning and relevant context.	Mostly accurate with minor omissions in problem framing.	Basic attempt with some gaps in understanding.	Concept is unclear or not properly defined.
Data handling / model setup	Uses data or model inputs accurately, neatly, and professionally.	Mostly correct with minor errors in data handling or setup.	Partially correct with some technical mistakes.	Incorrect, incomplete, or missing data/model setup.
Analysis and interpretation	Provides insightful analysis, logical interpretation, and sound conclusions.	Covers analysis adequately with limited depth.	Weak analysis with limited interpretation.	No meaningful analysis or interpretation.

Criteria	4 – Excellent	3 – Good	2 – Fair	1 – Needs Improvement
Presentation and clarity	Well-organized, easy to follow, and professionally presented.	Generally clear with minor formatting issues.	Understandable but somewhat untidy.	Very unclear, incomplete, or poorly presented.

MEMBRANE TECHNOLOGIES IN WATER AND WASTEWATER TREATMENT			
Course Code	**1MCEE205B**	Scheme	2026
Type of Course	**PEC**	Semester	II
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per semester L /T/P/SL&TW:	90(42:0:0:48)	SEE Marks	50
Credits	**3**	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

Course outcome (Course Skill Set)

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

1. CO1 L2-Understand: Explain the basic principles, membrane materials, and classifications of membrane processes.
2. CO2 L3-Apply: Apply pressure-driven and non-pressure-driven membrane processes for water and wastewater treatment.
3. CO3 L4-Analyse: Analyze membrane fouling, concentration polarization, and performance factors in membrane systems.
4. CO4 L5-Evaluate: Evaluate hybrid membrane systems and process configurations for industrial wastewater reuse.
5. CO5 L6-Create: Design a membrane-based treatment scheme for a selected water or wastewater stream.

Module-1

Fundamentals of Membrane Technology:

Introduction to membrane separation, historical development, membrane materials, membrane morphology, transport mechanisms, and membrane properties. Classification of membranes based on structure, material, and driving force. Membrane modules, operational parameters, and key performance indicators. Applications in drinking water, wastewater reclamation, and industry.

CO link: CO1 **Number of Hours: 08**

Module-2

Pressure-Driven Membrane Processes:

Microfiltration, ultrafiltration, nanofiltration, and reverse osmosis: principles, pore-size range, separation mechanisms, operating pressure, and applications. Pretreatment requirements, multi-barrier treatment concepts, and role of MF/UF as pre-treatment to NF/RO. Desalination and reuse applications in municipal, textile, food, pharmaceutical, and chemical industries.

CO link: CO2 **Number of Hours: 09**

Module-3

Non-Pressure and Electro-Membrane Processes:

Forward osmosis, electrodialysis, electrodialysis reversal, and pervaporation. Draw solution concepts, ion-exchange membranes, process performance, and suitability for challenging wastewaters. Comparison of energy demand, recovery potential, and contaminant selectivity. Industrial relevance in desalination, nutrient recovery, and high-salinity waste streams.

CO link: CO2, CO3 **Number of Hours: 09**

Module-4

Fouling, Cleaning, and Hybrid Systems:

Membrane fouling types: organic, inorganic, colloidal, biofouling, and scaling. Concentration polarization, flux decline, cleaning-in-place, chemical and physical cleaning, and fouling control strategies. Hybrid systems such as coagulation–UF, activated carbon–MF/UF, FO–RO, and membrane bioreactors. Process integration for improved sustainability, footprint reduction, and compliance with reuse standards.

CO link: CO3, CO4 **Number of Hours: 9**

Module-5

Advanced and Emerging Membrane Applications:
Membrane bioreactors, membrane distillation, advanced surface modification, anti-fouling membranes, resource recovery, and circular economy applications. Case studies from industrial wastewater, produced water, textile effluents, dairy wastewater, and municipal reuse. Techno-economic aspects, sustainability considerations, SDGs, and future trends in smart and energy-efficient membrane systems.

CO link: CO4, CO5 **Number of Hours:8**

Suggested Learning Resources:

Textbooks

1. Membrane Technology and Applications, Richard W. Baker.
2. Membrane Separation Principles and Applications, J. G. Crespo and K. W. Boddeke.
3. Wastewater Treatment and Water Reuse by Metcalf & Eddy / related membrane-focused editions.
4. Membrane Processes in Water and Wastewater Treatment, recent advanced engineering text or handbook.
5. Water Reclamation and Sustainability through Membrane Processes, selected reference compendium.

Reference Books:

1. Membrane Technologies in Wastewater Treatment: A Review, journal article on membrane processes and fouling.
2. Membrane-based water and wastewater treatment technologies: Issues, current trends, challenges, and role in achieving sustainable development goals.
3. Emerging and advanced membrane technology for wastewater treatment: A review.
4. Advanced Membrane Technologies for Wastewater Treatment and Resource Recovery.
5. Tuning of polymeric membranes to mitigate fouling and removal of dissolved compounds for wastewater treatment.

Web Links and e-Resources:

1. Membranes journal
2. PubMed Central membrane review article
3. ScienceDirect review on membrane-based water and wastewater treatment technologies
4. Frontiers review on fouling mitigation
5. [NPTEL / SWAYAM related membrane and water treatment resources]

Teaching-Learning Process (Innovative Delivery Methods):

- Flipped classroom.
- Problem-based learning.
- Case-based teaching.
- Simulation and software-based exercises.
- ICT-enabled teaching.
- Field data interpretation and mini-projects.

Suggested strategies:

- Conceptual lectures supported by industrial case studies.
- Demonstrations using membrane modules, plant diagrams, and process-flow charts.
- Problem-based learning on membrane selection for specific wastewaters.
- Case studies on RO, MBR, and hybrid systems in reuse applications.
- Seminars and mini-projects on fouling control and sustainable treatment trains

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]
A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.
In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks.

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	Compare MF, UF, NF, and RO for a given industrial wastewater stream.	24
2	Develop a membrane-based treatment train for textile or dairy wastewater.	24
3	Prepare a fouling diagnosis and cleaning strategy for an RO or UF unit.	24
4	Analyze a case study of MBR or FO-RO hybrid reuse system.	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	Study recent membrane surface modification techniques for antifouling.	24
2	Review one industrial membrane installation and summarize performance and limitations.	24
3	Prepare a note on membrane distillation or electrodialysis in water reuse.	24

Rubric for TW Activities:

Criteria	4 – Excellent	3 – Good	2 – Fair	1 – Needs Improvement
Problem understanding	Clearly defines the environmental issue with strong reasoning and relevant context.	Mostly accurate with minor omissions in problem framing.	Basic attempt with some gaps in understanding.	Concept is unclear or not properly defined.
Data handling / model setup	Uses data or model inputs accurately, neatly, and professionally.	Mostly correct with minor errors in data handling or setup.	Partially correct with some technical mistakes.	Incorrect, incomplete, or missing data/model setup.
Analysis and interpretation	Provides insightful	Covers analysis	Weak analysis with limited	No meaningful analysis or interpretation.

Criteria	4 – Excellent	3 – Good	2 – Fair	1 – Needs Improvement
	analysis, logical interpretation, and sound conclusions.	adequately with limited depth.	interpretation.	
Presentation and clarity	Well-organized, easy to follow, and professionally presented.	Generally clear with minor formatting issues.	Understandable but somewhat untidy.	Very unclear, incomplete, or poorly presented.

Sample Rubrics for TW

Criterion	Weight (%)	4 — Excellent (16–20 pts)	3 — Good (12–15 pts)	2 — Satisfactory (8–11 pts)	1 — Needs Improvement (0–7 pts)
Technical Knowledge & Accuracy	20	Demonstrates comprehensive, correct understanding of concepts and methods; all technical claims supported by data/literature.	Shows good understanding with minor errors; most claims supported.	Basic understanding; some technical errors or omissions.	Major conceptual errors or misconceptions; unsupported claims.
Data Analysis & Interpretation	20	Analysis is rigorous, appropriate methods chosen, results interpreted insightfully with clear linkage to objectives.	Analysis is appropriate with reasonable interpretation; minor gaps.	Basic analysis with limited interpretation; some wrong inferences.	Inadequate or incorrect analysis; interpretations unsupported.
Problem Solving & Innovation	15	Presents creative, effective solutions or improvements; demonstrates original thinking and feasibility assessment.	Provides logical, useful solutions with moderate innovation.	Solutions are routine and only partly effective.	Little or no problem-solving; suggested solutions impractical.
Teamwork & Participation	15	All members contribute actively and equitably; excellent coordination and role distribution documented.	Most members contribute; coordination good.	Uneven participation; some members passive.	Poor participation; team dysfunction; missing contributions.
Report Quality & Documentati	10	Well-structured, clear, professional report; references	Clear report with minor formatting/reference	Adequate report; missing citations or	Poorly written, incomplete, or missing

Criterion	Weight (%)	4 — Excellent (16–20 pts)	3 — Good (12–15 pts)	2 — Satisfactory (8–11 pts)	1 — Needs Improvement (0–7 pts)
on		complete and formatted; data reproducible.	issues.	moderate structure problems.	references/data.
Presentation & Communication	10	Clear, engaging oral/visual presentation; answers questions confidently; visuals professional.	Clear presentation; answers most questions; visuals acceptable.	Presentation understandable but lacks clarity or polish.	Unclear or disorganized presentation; poor response to questions.
Timeliness & Compliance	10	Submitted on time; follows all instructions and deliverable formats precisely.	Submitted on time with minor instruction deviations.	Late submission or missed minor requirements.	Significantly late or fails to meet core requirements.
Total	100	—	—	—	—

HYDRAULICS OF ENVIRONMENTAL SYSTEMS			
Course Code	**1MCEE205C**	Scheme	2026
Type of Course	**PEC**	Semester	II
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per semester L /T/P/SL&TW:	90(42:0:0:48)	SEE Marks	50
Credits	**3**	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

Course outcome (Course Skill Set)

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

1. Explain the fundamentals of hydraulics relevant to environmental systems, including pressure, flow, energy, and head losses.
2. Analyze flow in pipes, channels, and hydraulic structures used in water supply, drainage, and wastewater systems.
3. Evaluate hydraulic performance of environmental components such as pumps, conduits, open channels, and treatment units.
4. Design and select hydraulic elements for environmental systems using codal provisions, design standards, and sustainability considerations.
5. Apply hydraulic principles to real-world environmental engineering problems involving stormwater, sewage, flooding, and pollution transport.
6. Interpret operational data and use digital tools for monitoring, optimization, and quality assurance in environmental hydraulic systems.

Module-1

Fundamentals of Hydraulics for Environmental Systems:

- Properties of fluids relevant to environmental engineering.
- Pressure, hydrostatic force, buoyancy, and stability of submerged bodies.
- Fluid flow concepts: discharge, velocity, continuity equation, Bernoulli's theorem, energy and head losses.
- Flow regimes and dimensionless numbers relevant to water and wastewater systems.
- Practical relevance of hydraulics in water supply, sanitation, drainage, and pollution control systems.
- Introduction to sustainability and water-energy nexus in hydraulic system design.

Linked COs: CO1, CO5 **Number of Hours: 08**

Module-2

Pipe Flow, Pumps, and Conveyance Systems:

- Laminar and turbulent flow in pipes.
- Major and minor losses in pipelines.
- Pipe network basics, distribution systems, and pressure management.
- Pump characteristics, performance curves, selection, and operating range.
- Pumping systems for raw water, treated water, sewage, and sludge transport.
- Cavitation, air locking, surge, and control measures.
- Energy efficiency, leak reduction, and operational reliability in conveyance systems.

Linked COs: CO2, CO4, CO6 **Number of Hours:** 09

Module-3

Open Channel Hydraulics and Stormwater Systems:

- Uniform and non-uniform flow in open channels.
- Chezy and Manning equations; hydraulic radius and roughness.
- Specific energy, critical flow, hydraulic jump, and energy dissipation.
- Design aspects of drains, sewers, canals, and stormwater channels.
- Flow measurement in open channels and control structures.
- Urban runoff, flood conveyance, and drainage performance under extreme rainfall.
- Use of hydraulic modeling for stormwater planning.

Linked COs: CO2, CO5, CO6 **Number of Hours: 09**

Module-4

Hydraulics in Water and Wastewater Treatment Systems:

- Hydraulic design basis of water treatment plant units and wastewater treatment units.
- Flow distribution, head loss, detention time, and hydraulic efficiency.
- Hydraulic design of sedimentation tanks, filters, aeration units, clarifiers, reactors, and channels.
- Pipe and channel arrangements in treatment plants.
- Sludge conveyance, pumping, and flow control in treatment systems.
- Causes of hydraulic short-circuiting, dead zones, and poor performance.
- Basic instrumentation and monitoring for plant hydraulic control.

Linked COs: CO3, CO4, CO6 **Number of Hours:** 08

Module-5

Environmental Applications, Sustainability, and Digital Practice:

- Hydraulics of river pollution dispersion, mixing zones, and environmental flow concepts.
- Flood mitigation, retention, detention, recharge, and green infrastructure.
- Hydraulic considerations in wetlands, stormwater harvesting, and decentralized treatment systems.
- Design for climate resilience, resource efficiency, and circular water management.
- Introduction to digital tools for hydraulic analysis, sensor-based monitoring, SCADA, and simple data analytics.
- Case studies on urban drainage failures, treatment plant hydraulic issues, and sustainable retrofit solutions.

Linked COs: CO5, CO6 **Number of Hours: 08**

Suggested Learning Resources:

Textbooks

1. R.K. Bansal, *A Textbook of Fluid Mechanics and Hydraulic Machines*.
2. P.N. Modi and S.M. Seth, *Hydraulics and Fluid Mechanics*.
3. K. Subramanya, *Flow in Open Channels*.
4. Larry W. Mays, *Water Resources Engineering*.

Reference Books:

1. C.S.P. Ojha et al., *Hydraulics and Hydraulic Machines*.
2. M. Hanif Chaudhry, *Open-Channel Flow*.
3. Relevant CPHEEO manuals, BIS codes, and design standards for water supply, sewerage, drainage, and pumping systems.
4. Manuals and design guidance from pollution control, urban flooding, and stormwater management agencies.

Web Links and e-Resources:

1. NPTEL/SWAYAM courses on fluid mechanics, hydraulics, open-channel flow, and environmental engineering.
2. CPCB/CPHEEO manuals and municipal drainage design resources.
3. Industry case studies on pumping stations, stormwater systems, and wastewater hydraulics.

Teaching-Learning Process (Innovative Delivery Methods):

- Flipped classroom.
- Problem-based learning.
- Case-based teaching.
- Simulation and software-based exercises.
- ICT-enabled teaching.
- Field data interpretation and mini-projects.

Suggested strategies:

- Flipped classroom on flow fundamentals and hydraulic losses.
- Problem-based learning on pump failure, sewer surcharge, flooding, and treatment plant hydraulic inefficiency.
- Case-based teaching using real water supply, stormwater, and wastewater systems.
- Simulation/virtual labs for pipe networks, channel flow, and pump selection.
- Industrial visit to pumping stations, STPs, WTPs, and stormwater infrastructure.
- ICT-enabled teaching using hydraulic software, sensor dashboards, and flow data interpretation.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks.

Students' activities for TW/SL under NCrF: Samples only:

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**TW1 – Local water system survey:** Map a local water supply, drainage, or sewage conveyance system and identify hydraulic components, bottlenecks, and improvement needs.	24
2	**TW2 – Pipe/pump case study:** Analyze a pumping or pipeline system for head loss, energy use, and operational issues.	24
3	**TW3 – Stormwater/flood case study:** Study a drainage failure or urban flooding event and propose hydraulic remedies.	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**

1	**SL1 – Code and manual review:** Review relevant CPHEEO/BIS/municipal guidance and prepare a reflective note.	24
2	**SL2 – Digital tool review:** Study one hydraulic modeling or monitoring tool used in environmental systems and summarize its use in practice.	24
3	**SL3 – MOOC/video module:** Complete a short module on open-channel flow, pumping, or environmental hydraulics and submit a learning note.	24

Sample Rubrics for SW:

Criterion	**4 – Excellent**	**3 – Good**	**2 – Satisfactory**	**1 – Needs Improvement**
Problem understanding	Problem is clearly defined with strong justification and clear objectives.	Problem is mostly clear with minor gaps in framing or justification.	Problem is stated but lacks clarity or detailed justification.	Problem is poorly defined or unclear.
Data and method	Data collected/used is appropriate and sufficient; methods/tools are well chosen and logically applied.	Data and methods are generally appropriate with minor issues or omissions.	Limited or partially relevant data; methods are basic or inconsistently applied.	Data is inadequate/irrelevant; methods are inappropriate or missing.
Analysis	Analysis is thorough; interpretations are logically argued and results are valid.	Analysis is generally sound with minor errors or missing details.	Analysis is partial; contains gaps or superficial interpretation.	Analysis is weak, incorrect, or largely missing.
Recommendations	Recommendations are feasible, context-specific, and clearly derived from analysis.	Recommendations are relevant but may have minor limitations or lack detail.	Recommendations are generic or only loosely connected to analysis.	Recommendations are incomplete, unrealistic, or absent.
Presentation	Work is very well organized, neat, and professionally presented.	Work is well organized with minor issues in formatting or clarity.	Presentation is acceptable but uneven; structure or formatting needs improvement.	Work is poorly organized, difficult to follow, or untidy.

ENVIRONMENTAL POLLUTION MONITORING & SENSORS			
Course Code	**1MCEE205D**	Scheme	2026
Type of Course	**PEC**	Semester	II
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per semester L /T/P/SL&TW:	90(42:0:0:48)	SEE Marks	50
Credits	**3**	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

Course outcome (Course Skill Set)

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

1. CO1: Explain the sources, transport mechanisms, and impacts of major environmental pollutants in air, water, and soil, and relate them to regulatory standards and monitoring needs.
2. CO2: Distinguish among conventional and modern methods of environmental sampling, preservation, and analysis for pollution assessment.
3. CO3: Evaluate the performance, calibration, and limitations of environmental sensors and monitoring instruments used for air, water, and soil quality assessment.
4. CO4: Select appropriate monitoring strategies, sensor systems, and analytical methods for specific environmental quality parameters and compliance requirements.
5. CO5: Interpret environmental monitoring data to identify pollution trends, exceedances, and likely sources, and recommend suitable mitigation measures.
6. CO6: Demonstrate familiarity with data logging, wireless monitoring, IoT-enabled sensing, and sustainability-oriented environmental management practices.

Module-1

Environmental Pollution Basics and Monitoring Framework:

- Environmental pollution: definition, classification, sources, pathways, receptors, and impacts on ecosystems and human health.
- Air, water, soil, and noise pollution: major pollutants, indicator parameters, and significance of monitoring.
- Environmental quality standards: overview of CPCB/SPCB norms, ambient standards, and discharge limits.
- Sampling concepts: representative sampling, grab and composite samples, frequency, chain of custody, and field safety.
- Introduction to monitoring networks: fixed stations, mobile monitoring, passive samplers, and citizen-sensing concepts.
- Environmental sensor systems: basic principles, transducers, signal conditioning, and data acquisition.

Linked COs: CO1, CO2, CO4. **Number of Hours: 08**

Module-2

Air Pollution Monitoring and Sensors:

- Air pollutants: particulate matter, SOx, NOx, CO, O3, VOCs, NH3, and greenhouse gases; sources and health impacts.
- Air quality index and regulatory monitoring requirements.
- Sampling and analysis methods: gravimetric PM measurement, gas absorption methods, and reference instruments.
- Sensors for air monitoring: electrochemical, optical, metal oxide semiconductor, NDIR, and photoionization sensors.
- PM sensing: light scattering principle, PM2.5/PM10 measurement, calibration issues, and environmental interferences.
- Station design and data handling: placement, meteorological influences, data validation, and maintenance.

Linked COs: CO2, CO3, CO5, CO6. **Number of Hours: 08**

Module-3

Water and Wastewater Quality Monitoring:

- Water pollution sources: domestic, industrial, agricultural, and urban runoff.
- Key water quality parameters: pH, turbidity, conductivity, TDS, DO, BOD, COD, nutrients, heavy metals, and microbial indicators.
- Sampling and preservation of water and wastewater samples.
- Sensors and analyzers: pH, ORP, conductivity, dissolved oxygen, turbidity, ion-selective electrodes, and online analyzers.
- Monitoring of treatment systems: inlet/outlet quality, process control, alarms, and real-time systems.
- Limitations of field sensors, fouling, drift, and maintenance requirements.

Linked COs: CO2, CO3, CO4, CO5. **Number of Hours: 08**

Module-4

Soil, Noise, and Radiation Monitoring:

- Soil pollution: sources, contaminants, and effects on fertility, groundwater, and human exposure.
- Soil monitoring parameters: pH, EC, moisture, salinity, nutrients, hydrocarbons, and heavy metals.
- Soil sensor technologies: moisture probes, ion sensors, spectroscopic methods, and portable analyzers.
- Noise pollution monitoring: sound pressure level, frequency weighting, dosimeters, and monitoring procedures.
- Radiation and special hazard monitoring: basic concepts of ionizing radiation, detectors, and safety precautions.
- Portable and field-deployable instrumentation, calibration, and quality assurance.

Linked COs: CO3, CO4, CO6. **Number of Hours: 08**

Module-5

IoT-Based Environmental Monitoring and Data Analytics:

- Wireless sensor networks for environmental monitoring: architecture, communication protocols, edge devices, and gateways.
- IoT platforms for real-time monitoring, dashboards, alerts, and remote data access.
- Data logging and analytics: trend analysis, anomaly detection, exceedance interpretation, and visualization.
- Sensor calibration, uncertainty, QA/QC, and maintenance planning.
- Applications in smart cities, industrial compliance, watershed monitoring, and campus sustainability.
- Emerging trends: low-cost sensors, machine learning for pollution prediction, and integrated monitoring frameworks.

Linked COs: CO4, CO5, CO6. **Number of Hours: 08**

Suggested Learning Resources:

Textbooks

1. C.S. Rao, *Environmental Pollution Control Engineering*, New Age International.
2. Peavy, Rowe and Tchobanoglous, *Environmental Engineering*, McGraw Hill.
3. James R. Mihelcic and J. B. Zimmerman, *Environmental Engineering: Fundamentals, Sustainability, Design*, Wiley.
4. G.M. Masters and W.P. Ela, *Introduction to Environmental Engineering and Science*, Pearson.

Reference Books:

1. P. Venugopala Rao, *Principles of Environmental Engineering and Science*.
2. S.K. Dhameja, *Environmental Engineering and Pollution Control*.
3. Standard methods for examination of water and wastewater.
4. CPCB manuals, ambient air quality standards, and monitoring guidelines.
5. BIS/ISO standards relevant to environmental sampling and sensor calibration.
6. IoT and sensor technology handbooks for environmental applications.

Web Links and e-Resources:

1. CPCB and SPCB portals for standards, guidelines, and monitoring reports.
2. NPTEL/SWAYAM courses on environmental engineering, air pollution, and sensing systems.
3. WHO and UNEP resources on pollution assessment and environmental health.
4. Online tutorials on IoT dashboards, sensor calibration, and data visualization.

Teaching-Learning Process (Innovative Delivery Methods):

- Flipped classroom.
- Problem-based learning.
- Case-based teaching.
- Simulation and software-based exercises.
- ICT-enabled teaching.
- Field data interpretation and mini-projects.

Suggested strategies:

- Problem-based learning on air, water, or soil pollution incidents where students identify sources, select sensors, and propose controls.
- Case-based teaching using real pollution episodes, treatment plant monitoring, or industrial compliance scenarios.
- Simulation and virtual labs for calibration, sampling, and sensor data interpretation.
- Partial delivery by industry experts from pollution control boards, laboratories, smart-city projects, or environmental consultancies.
- ICT-enabled teaching using online dashboards, videos, and open environmental datasets.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks.

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**TW1 – Pollution Source Survey and Mapping Exercise:** Collect data on local air, water, or soil pollution sources; map hotspots; present findings using tables/charts. Linked COs: **CO1, CO4**.	24
2	**TW2 – Sensor Selection and Field Monitoring Study:** Study or simulate monitoring of one environmental parameter using appropriate sensors; document calibration, data collection, and limitations. Linked COs: **CO2, CO3, CO6**.	24
3	**TW3 – Environmental Case Study and Mitigation Plan:** Undertake a mini-project on a pollution issue using monitoring data and recommend control measures. Linked COs: **CO5, CO6**.	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	**SL1 – Standards and Guidelines Review:** Read relevant CPCB/WHO/BIS/ISO standards and prepare a reflective note on monitoring implications. Linked COs: **CO1, CO4**.	24
2	**SL2 – Sensor Technology Review:** Review one environmental sensor or monitoring platform and summarize its advantages, limitations, and applications. Linked COs: **CO3, CO6**.	24
3	**SL3 – MOOC/Video Module on Environmental Monitoring:** Complete a MOOC or video module on pollution monitoring, data analytics, or smart sensing and submit a learning note. Linked COs: **CO5, CO6**.	24

Sample Rubrics for TW:

Criterion	4 – Excellent	3 – Good	2 – Satisfactory	1 – Needs Improvement
Problem understanding	Problem is clearly defined with strong justification and clear objectives.	Problem is mostly clear with minor gaps in framing or justification.	Problem is stated but lacks clarity or detailed justification.	Problem is poorly defined or unclear.
Data and method	Data collected/used is appropriate and sufficient; methods/tools are well chosen and logically applied.	Data and methods are generally appropriate with minor issues or omissions.	Limited or partially relevant data; methods are basic or inconsistently applied.	Data is inadequate/irrelevant; methods are inappropriate or missing.
Analysis	Analysis is thorough; interpretations are logically argued and results are valid.	Analysis is generally sound with minor errors or missing details.	Analysis is partial; contains gaps or superficial interpretation.	Analysis is weak, incorrect, or largely missing.
Recommendations	Recommendations are feasible, context-specific, and clearly derived from analysis.	Recommendations are relevant but may have minor limitations or lack detail.	Recommendations are generic or only loosely connected to analysis.	Recommendations are incomplete, unrealistic, or absent.
Presentation	Work is very well organized, neat, and professionally presented.	Work is well organized with minor issues in formatting or clarity.	Presentation is acceptable but uneven; structure or formatting needs improvement.	Work is poorly organized, difficult to follow, or untidy.

AIR QUALITY MODELLING, MANAGEMENT AND NOISE POLLUTION CONTROL			
Course Code	**1MCEE206A**	Scheme	2026
Type of Course	**PEC**	Semester	II
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per semester L /T/P/SL&TW:	90(42:0:0:48)	SEE Marks	50
Credits	**3**	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

Course outcome (Course Skill Set)

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

1. CO1: Explain the sources, characteristics, and effects of air pollutants and noise on human health and the environment.
2. CO2: Analyse atmospheric conditions, sampling data, and dispersion behavior to assess air quality and pollution impacts.
3. CO3: Apply air quality modelling concepts to estimate pollutant dispersion from point, line, and area sources.
4. CO4: Select suitable control methods and management measures for particulate, gaseous, vehicular, indoor air, and noise pollution.
5. CO5: Evaluate air quality monitoring strategies, regulatory standards, and environmental management practices for pollution reduction.
6. CO6: Demonstrate familiarity with sustainable pollution management tools, noise monitoring, and control technologies in real-world applications.

Module-1

Introduction to Air Pollution and Air Quality Management:

- Structure and composition of atmosphere; sources, classification, and characteristics of air pollutants.
- Effects of air pollutants on human health, vegetation, animals, materials, soil, water bodies, and climate.
- Atmospheric stability, lapse rate, inversion, wind profile, turbulence, plume behaviour, and mixing height.
- Ambient air quality standards, emission standards, air pollution indices, emission inventory, and basic regulatory framework.
- Air quality management concepts in urban, rural, and industrial settings; role of policies, planning, and enforcement.

Linked COs: CO1, CO2, CO5. **Number of Hours: 08**

Module-2

Air Quality Monitoring, Sampling and Data Interpretation:

- Objectives of air quality monitoring; temporal and spatial variability of pollutants.
- Ambient, stack, and indoor air sampling methods for particulate and gaseous pollutants.
- Sampling network design, monitoring station selection, frequency, and quality assurance in air monitoring.
- Analysis and interpretation of air pollution data; trend identification, exceedance assessment, and reporting.
- Air quality instrumentation, particulate and gas analyzers, and introduction to air quality indices and dashboards.

Linked COs: CO2, CO5, CO6. **Number of Hours: 09**

Module-3

Air Quality Modelling and Dispersion Analysis:

- Need, objectives, and classification of air quality models.
- Box models, Gaussian plume model, and assumptions; model inputs and limitations.
- Effects of plume rise, stack height, ground reflection, line sources, and complex terrain.
- Modeling from point, line, and area sources; regulatory and screening models.
- Introduction to indoor air quality modelling and interpretation of model outputs for planning and control.

Linked COs: CO2, CO3, CO5. **Number of Hours: 09**

Module-4

Air Pollution Control and Management Measures:

- Control at source: process modification, cleaner fuels, raw material substitution, and housekeeping.
- Particulate control devices: settling chambers, cyclones, fabric filters, wet scrubbers, and ESPs.
- Gaseous pollutant control: absorption, adsorption, condensation, incineration, and bio-filtration.
- Vehicular pollution control, industrial emission management, and indoor air pollution control measures.
- Environmental management tools: maintenance planning, compliance monitoring, audit, and emergency response.

Linked COs: CO4, CO5, CO6. **Number of Hours:** 08

Module-5

Noise Pollution and Control:

- Fundamentals of acoustics: sound pressure, sound intensity, sound power, decibel scale, and weighting.
- Sources and characteristics of noise from transportation, construction, industry, and communities.
- Noise propagation, indoor and outdoor noise, annoyance, health effects, and noise exposure concepts.
- Noise standards, measurement procedures, noise indices, and noise mapping basics.
- Control of noise at source, along transmission path, and at receiver; silencers, barriers, enclosures, and PPE.

Linked COs: CO1, CO4, CO6. **Number of Hours: 08**

Suggested Learning Resources:

Textbooks

1. M.N. Rao and H.V.N. Rao, *Air Pollution*.
2. Noel de Nevers, *Air Pollution Control Engineering*.
3. Anjaneyulu Y., *Textbook of Air Pollution and Control Technologies*.
4. Tr. B. etc. on acoustics and environmental pollution if institutionally preferred.
5. Wark, K., Warner, C.F., and Davis, W.T., (1998), "Air Pollution- Its Origin and Control" 3rd edition, Harper & Row Publishers, New York.
6. Stern A.C, Boubel R.W, Turner D.B., Fox D.L (1984) "Fundamentals of Air Pollution" Second edition Academic Press Inc.

Reference Books:

1. Rao and Rao, *Air Pollution Control* references and related environmental engineering texts.
2. Boubel, Fox, Turner and Stern, *Fundamentals of Air Pollution*.
3. Relevant BIS/PCB standards on ambient air quality and noise.
4. CPCB/State Pollution Control Board manuals and guidelines.
5. Rao, C. S., Environmental Pollution Control Engineering, New Age Int. Pubs, 1991, Reprint, 2005.
6. Colls, J., Abhishek T, Air Pollution: Measurement, Modelling and Mitigation, ISBN13: 978-0- 415- 47932-5 CRC Press, 2009.

Web Links and e-Resources:

1. NPTEL/SWAYAM courses on air pollution, environmental management, and acoustics.
2. CPCB and SPCB portals for standards, indices, and monitoring guidance.
3. WHO resources on air quality and environmental noise.

Teaching-Learning Process (Innovative Delivery Methods):

- Flipped classroom.
- Problem-based learning.
- Case-based teaching.
- Simulation and software-based exercises.
- ICT-enabled teaching.
- Field data interpretation and mini-projects.

Suggested strategies:

- PBL on urban smog, industrial stack emissions, or traffic-related noise hotspots.
- Case studies using real AQI data, dispersion scenarios, and mitigation planning.

- Virtual demonstrations of stack sampling, ambient monitoring, and noise mapping.
- Industrial visits to monitoring stations, CETPs, industries, and traffic corridors.
- Expert sessions from environmental consultants, pollution control officers, and auditors.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks.

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**TW1 – Air Quality Data Profiling Exercise**: Collect AQI or pollutant data from a local area, compare with standards, and present findings using tables/charts. Linked COs: CO2, CO5.	24
2	**TW2 – Dispersion and Source Study:** Analyse a point/line/area source scenario and estimate likely dispersion patterns using simple model assumptions or case data. Linked COs: CO2, CO3.	24
3	**TW3 – Noise Survey and Control Case Study:** Conduct a noise measurement survey in a traffic, campus, or industrial setting and propose control measures. Linked COs: CO1, CO4, CO6.	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	**SL1 – Standards and Policy Review:** Read relevant ambient air quality and noise standards, and prepare a reflective note on their application. Linked COs: CO5, CO6.	24
2	**SL2 – Model/Technology Review:** Review one air quality model or pollution control technology and summarize advantages, limitations, and implementation issues. Linked COs: CO3, CO4.	24
3	**SL3 – MOOC/Video Module on Environmental Noise or Air Monitoring:** Complete a MOOC/video module and submit a learning note. Linked COs: CO1, CO6.	24

Sample Rubrics for TW:

Criterion	4 – Excellent	3 – Good	2 – Satisfactory	1 – Needs Improvement
Problem understanding	Problem is clearly defined with strong justification and clear objectives.	Problem is mostly clear with minor gaps in framing or justification.	Problem is stated but lacks clarity or detailed justification.	Problem is poorly defined or unclear.
Data and method	Data collected/used is appropriate and sufficient; methods/tools are well chosen and logically applied.	Data and methods are generally appropriate with minor issues or omissions.	Limited or partially relevant data; methods are basic or inconsistently applied.	Data is inadequate/irrelevant; methods are inappropriate or missing.
Analysis	Analysis is thorough; interpretations are logically argued and results are valid.	Analysis is generally sound with minor errors or missing details.	Analysis is partial; contains gaps or superficial interpretation.	Analysis is weak, incorrect, or largely missing.
Recommendations	Recommendations are feasible, context-specific, and clearly derived from analysis.	Recommendations are relevant but may have minor limitations or lack detail.	Recommendations are generic or only loosely connected to analysis.	Recommendations are incomplete, unrealistic, or absent.
Presentation	Work is very well organized, neat, and professionally presented.	Work is well organized with minor issues in formatting or clarity.	Presentation is acceptable but uneven; structure or formatting needs improvement.	Work is poorly organized, difficult to follow, or untidy.

GEOSPATIAL TECHNIQUES FOR ENVIRONMENTAL SYSTEMS			
Course Code	**1MCEE206B**	Scheme	2026
Type of Course	**PEC**	Semester	II
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per semester L /T/P/SL&TW:	90(42:0:0:48)	SEE Marks	50
Credits	**3**	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

Course outcome (Course Skill Set)

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

1. **CO1:** Explain fundamental geospatial concepts, coordinate systems, map projections, and spatial data types used in environmental analysis.
2. **CO2:** Acquire, preprocess, and manage geospatial data from remote sensing, GPS, GIS, and open-source platforms for environmental applications.
3. **CO3:** Analyze environmental phenomena using spatial analysis, terrain modeling, and remote sensing interpretation techniques.
4. **CO4:** Apply GIS and geospatial tools for environmental planning, watershed analysis, land-use assessment, and hazard mapping.
5. **CO5:** Evaluate environmental change, vulnerability, and sustainability using geospatial techniques and decision-support approaches.
6. **CO6:** Demonstrate familiarity with modern geospatial workflows, cloud-based platforms, standards, and ethical use of spatial data in environmental systems.

Module-1

Fundamentals of Geospatial Systems and Environmental Applications:

- Introduction to geospatial techniques: GIS, remote sensing, GPS, GNSS, and spatial decision support systems.
- Components of GIS: hardware, software, data, people, and methods; vector and raster data models.
- Coordinate systems, datums, map projections, scales, and spatial referencing.
- Spatial data sources for environmental systems: survey data, satellite data, drone data, open data portals, and field observations.
- Environmental applications of geospatial techniques in land, water, air, biodiversity, and disaster management.
- Basics of data quality, metadata, and spatial data ethics.

Linked COs: CO1, CO6. **Number of Hours: 08**

Module-2

Remote Sensing for Environmental Observation:

- Principles of remote sensing: electromagnetic spectrum, interaction with atmosphere, vegetation, water, soil, and built environment.
- Platforms and sensors: satellites, aircraft, drones, multispectral and hyperspectral systems.
- Image characteristics: spatial, spectral, radiometric, and temporal resolution.
- Image preprocessing: correction, enhancement, georeferencing, mosaicking, and subsetting.
- Visual interpretation elements and digital image classification methods.
- Environmental applications: land-use/land-cover mapping, forest monitoring, water body assessment, pollution observation, and climate-related studies.

Linked COs: CO2, CO3. **Number of Hours: 09**

Module-3

GIS Data Handling and Spatial Analysis:

- GIS data creation, import, editing, and database management.
- Attribute data, topology, joins, queries, and relational concepts.
- Spatial analysis tools: buffer, overlay, proximity, network analysis, interpolation, and reclassification.
- Terrain analysis using DEM, slope, aspect, contouring, and watershed delineation.
- Environmental suitability analysis and multi-criteria decision-making basics.

- Introduction to open-source GIS tools and simple environmental case studies.

Linked COs: CO2, CO4, CO6. **Number of Hours: 08**

Module-4

Geospatial Techniques for Environmental Planning and Monitoring:

- Watershed and drainage analysis using GIS and remote sensing.
- Land-use planning, urban growth monitoring, and environmental impact assessment support.
- Mapping of floods, droughts, landslides, soil erosion, and heat islands.
- Monitoring surface water quality, groundwater potential zones, and catchment characteristics.
- Geospatial support for biodiversity mapping, habitat fragmentation, and ecological sensitivity assessment.
- Integration of geospatial outputs with environmental management and policy frameworks.

Linked COs: CO3, CO4, CO5. **Number of Hours:** 09

Module-5

Advanced Applications, Cloud GIS and Sustainability:

- Introduction to web GIS, cloud GIS, mobile GIS, and real-time environmental monitoring.
- Spatial data visualization, dashboards, and decision-support systems.
- GIS integration with IoT, AI, and machine learning for environmental prediction and monitoring.
- Geospatial approaches for sustainability assessment, SDGs, climate adaptation, and resilience planning.
- Ethical, legal, and governance issues in spatial data sharing and environmental intelligence.
- Case studies on river basin management, disaster preparedness, urban sustainability, and conservation planning.

Linked COs: CO5, CO6. **Number of Hours:** 08

Suggested Learning Resources:

Textbooks

1. Paul Bolstad, GIS Fundamentals: A First Text on Geographic Information Systems, latest edition.
2. John R. Jensen, Introductory Digital Image Processing, latest edition.
3. M. Anji Reddy, Textbook of Remote Sensing and Geographical Information Systems, latest edition.
4. C.P. Lo and Albert K.W. Yeung, Concepts and Techniques of Geographic Information Systems, latest edition.

Reference Books:

1. Burrough, P.A. and McDonnell, R.A., Principles of Geographical Information Systems.
2. George Joseph, Fundamentals of Remote Sensing.
3. Lillesand, Kiefer and Chipman, Remote Sensing and Image Interpretation.
4. Ian Heywood, Sarah Cornelius and Steve Carver, An Introduction to Geographical Information Systems.
5. Relevant ISRO, NRSC, BIS, and government spatial-data guidelines as applicable.

Web Links and e-Resources:

1. NPTEL/SWAYAM courses on GIS, remote sensing, and environmental remote sensing.
2. ISRO/NRSC/Bhuvan and other national geospatial portals.
3. Open-source GIS documentation and environmental geospatial case studies.
4. Government environmental data portals and spatial decision-support dashboards.

Teaching-Learning Process (Innovative Delivery Methods):

- Flipped classroom.
- Problem-based learning.
- Case-based teaching.
- Simulation and software-based exercises.
- ICT-enabled teaching.
- Field data interpretation and mini-projects**.**

Suggested strategies:

- Problem-based learning on flood mapping, groundwater assessment, or land-use change.
- Case-based teaching using urban expansion, watershed degradation, and pollution monitoring examples.
- Simulation and virtual labs using GIS software and satellite data processing tools.
- Expert lectures from GIS practitioners, environmental consultants, and remote sensing professionals.

- ICT-enabled teaching through online maps, dashboards, and virtual demonstrations of geospatial workflows..

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks.

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**TW1 – GIS-Based Environmental Mapping Exercise:** Collect and organize spatial data for a local environmental issue such as land-use change, flood-prone zones, groundwater potential, or waste dumping areas; prepare thematic maps and brief interpretation. Linked COs: CO2, CO4.	24
2	**TW2 – Remote Sensing Change Detection Study:** Analyze satellite images of an area across two time periods to identify changes in vegetation, water spread, urban growth, or surface condition; present findings with map outputs. Linked COs: CO3, CO5.	24
3	**TW3 – Environmental Hazard and Risk Mapping:** Develop a mini-project using GIS layers to prepare hazard/vulnerability maps for flood, landslide, erosion, or heat stress and recommend mitigation measures. Linked COs: CO4, CO5, CO6.	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	**SL1 – Standards and Data Policy Review:** Review relevant geospatial data standards, metadata practices, and environmental data sharing policies; prepare a reflective note. Linked COs: CO1, CO6.	24
2	**SL2 – Open-Source GIS Tool Review:** Explore one open-source GIS platform and document its use in environmental analysis, including advantages, limitations, and sample workflow. Linked COs: CO2, CO6.	24
3	**SL3 – MOOC/Video Module on Remote Sensing or GIS for Environment:** Complete an online module and submit a short learning note with one application case. Linked COs: CO3, CO5.	24

Sample Rubrics for TW:

Criterion	4 – Excellent	3 – Good	2 – Satisfactory	1 – Needs Improvement
Problem understanding	Problem is clearly defined with strong justification and clear objectives.	Problem is mostly clear with minor gaps in framing or justification.	Problem is stated but lacks clarity or detailed justification.	Problem is poorly defined or unclear.
Data and method	Data collected/used is appropriate and sufficient; methods/tools are well chosen and logically applied.	Data and methods are generally appropriate with minor issues or omissions.	Limited or partially relevant data; methods are basic or inconsistently applied.	Data is inadequate/irrelevant; methods are inappropriate or missing.
Analysis	Analysis is thorough; interpretations are logically argued and results are valid.	Analysis is generally sound with minor errors or missing details.	Analysis is partial; contains gaps or superficial interpretation.	Analysis is weak, incorrect, or largely missing.
Recommendations	Recommendations are feasible, context-specific, and clearly derived from analysis.	Recommendations are relevant but may have minor limitations or lack detail.	Recommendations are generic or only loosely connected to analysis.	Recommendations are incomplete, unrealistic, or absent.
Presentation	Work is very well organized, neat, and professionally presented.	Work is well organized with minor issues in formatting or clarity.	Presentation is acceptable but uneven; structure or formatting needs improvement.	Work is poorly organized, difficult to follow, or untidy.

AI & ML IN HYDROLOGY AND ENVIRONMENTAL MODELLING			
Course Code	**1MCEE206C**	Scheme	2026
Type of Course	**PEC**	Semester	II
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per semester L /T/P/SL&TW:	90(42:0:0:48)	SEE Marks	50
Credits	**3**	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

Course outcome (Course Skill Set)

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

1. **CO1:** Explain fundamental hydrologic and environmental processes and the role of data-driven methods in modelling them.
2. **CO2:** Apply preprocessing, feature selection, and exploratory analysis techniques to hydro-meteorological and environmental datasets.
3. **CO3:** Develop and evaluate basic machine learning models for prediction of hydrologic and environmental variables.
4. **CO4:** Integrate AI/ML methods with conceptual and numerical environmental models for forecasting and decision support.
5. **CO5:** Interpret model outputs for practical applications such as flood prediction, water quality assessment, drought monitoring, and pollution studies.
6. **CO6:** Demonstrate awareness of ethical, sustainability, uncertainty, and deployment issues in AI-based environmental modelling.

Module-1

Fundamentals of Hydrology and Environmental Systems:

- Hydrologic cycle, rainfall-runoff processes, evapotranspiration, infiltration, groundwater recharge, streamflow and watershed response.
- Environmental systems: surface water, groundwater, air quality, soil and ecosystem interactions.
- Sources of hydrometeorological and environmental data: gauges, sensors, satellites, reanalysis, IoT and citizen data.
- Data characteristics: temporal resolution, missing data, noise, bias, non-stationarity and uncertainty.
- Introduction to AI and ML in environmental applications, advantages, limitations and workflow.
- Overview of supervised, unsupervised and semi-supervised learning for hydrology and environment.

Linked COs: CO1, CO6. **Number of Hours: 08**

Module-2

Data Preparation and Feature Engineering:

- Data acquisition, cleaning, quality control and imputation techniques for environmental datasets.
- Time series handling: lag variables, rolling statistics, seasonality, trend and anomaly detection.
- Feature engineering for rainfall, runoff, groundwater, air quality and pollution prediction.
- Dimensionality reduction and feature selection methods.
- Exploratory data analysis, correlation, multicollinearity and normalization.
- Introduction to Python-based workflows, spreadsheets and open-source tools for environmental data analysis.

Linked COs: CO2, CO6. **Number of Hours: 08**

Module-3

Machine Learning Models for Prediction:

- Regression models for hydrology and environment: linear regression, decision trees, random forest, support vector regression and gradient boosting.
- Classification models for event detection: flood/no-flood, pollution alert, drought category and water quality class.
- Neural networks and basic deep learning concepts for environmental prediction.
- Model training, validation, test split, cross-validation and hyperparameter tuning.

- Performance metrics: RMSE, MAE, R^2, accuracy, precision, recall, F1-score and ROC-AUC.
- Overfitting, underfitting and model generalization.

Linked COs: CO3, CO5. **Number of Hours: 09**

Module-4

AI-Enhanced Hydrologic and Environmental Modelling:

- Conceptual, empirical and process-based models in hydrology and environment.
- Hybrid modelling: coupling ML with rainfall-runoff models, groundwater models and water quality models.
- Forecasting applications: flood forecasting, streamflow prediction, drought prediction and air pollution forecasting.
- Environmental state estimation and surrogate modelling.
- Uncertainty quantification, sensitivity analysis and explainable AI concepts.
- Introduction to model interpretability tools and decision support systems.

Linked COs: CO4, CO5, CO6. **Number of Hours:** 09

Module-5

Applications, Ethics and Deployment:

- Case studies in watershed management, urban flooding, water quality monitoring and climate impact studies.
- AI applications in environmental compliance, smart monitoring and early warning systems.
- Model deployment concepts: dashboards, APIs, cloud-based analytics and digital twins.
- Ethical issues: bias, transparency, data privacy, responsible AI and governance.
- Sustainability considerations, lifecycle thinking and integration with SDG-oriented environmental planning.
- Future trends: remote sensing analytics, physics-informed ML, foundation models and edge AI for environmental systems.

Linked COs: CO5, CO6. **Number of Hours:** 08

Suggested Learning Resources:

Textbooks

1. Solomatine, D.P. and Ostfeld, A., *Data-Driven Modelling in Hydrology and Hydraulics*, CRC Press.
2. Qihao Weng, *Remote Sensing and GIS Integration for Environmental Analysis*, CRC Press.
3. Gareth James, Daniela Witten, Trevor Hastie and Robert Tibshirani, *An Introduction to Statistical Learning*, Springer.
4. Christopher M. Bishop, *Pattern Recognition and Machine Learning*, Springer.

Reference Books:

1. John C. Reeves, *Artificial Intelligence in Environmental Modelling*, relevant editions.
2. Rajib Maity, *Statistical Methods in Hydrology and Hydroclimatology*, Springer.
3. ASCE Manuals and Reports on hydrologic and environmental modelling.
4. Relevant BIS/CGWB/CPCB/IMD publications and guidelines.
5. NPTEL/SWAYAM resources on machine learning, hydrology and environmental engineering.

Web Links and e-Resources:

1. NPTEL/SWAYAM courses on Machine Learning, Hydrology, and Environmental Data Analytics.
2. IMD, CPCB, CGWB, and ISRO/NRSC data portals for environmental datasets.
3. Open-source Python resources: NumPy, Pandas, Scikit-learn, TensorFlow, PyTorch and QGIS tutorials.

Teaching-Learning Process (Innovative Delivery Methods):

- Flipped classroom.
- Problem-based learning.
- Case-based teaching.
- Simulation and software-based exercises.
- ICT-enabled teaching.
- Field data interpretation and mini-projects**.**

Suggested strategies:

- Data-driven case studies on flood prediction, pollution forecasting and drought monitoring.

- Hands-on notebook-based exercises using real hydrological or environmental datasets.
- Mini-projects on model building, validation and interpretation.
- Demonstrations using open-source tools, dashboards and remote sensing data.
- Industrial or institutional visits to environmental monitoring laboratories where feasible

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks.

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	**TW1 – Hydro-Meteorological Data Profiling Exercise:** Collect rainfall, temperature, streamflow or water quality data from open sources; clean the dataset; present summary tables, trends and missing-data handling. Linked COs: CO2, CO3.	24
2	**TW2 – ML Model Development for a Hydrologic Problem:** Build and compare at least two predictive models for streamflow, flood risk, groundwater level or pollution concentration using a chosen dataset. **Linked COs:** CO3, CO4.	24
3	**TW3 – Environmental Case Study using AI/ML:** Undertake a mini-project on flood warning, drought classification, air quality forecasting or water quality prediction and interpret results for decision support. **Linked COs:** CO4, CO5, CO6.	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	**SL1 – Literature and Guideline Review:** Review papers, standards or policy documents on AI/ML applications in hydrology and environmental modelling and prepare a reflective note. **Linked COs:** CO1, CO6.	24
2	**SL2 – Software/Notebook Review:** Explore an open-source ML workflow for environmental prediction and summarize the preprocessing, training and evaluation steps. **Linked COs:** CO2, CO3, CO4.	24
3	**SL3 – MOOC/Video Module:** Complete a MOOC or video module on hydrologic modelling, data science or environmental AI and submit a learning note. **Linked COs:** CO3, CO6.	24

Sample Rubrics for TW

Criterion	4 – Excellent	3 – Good	2 – Satisfactory	1 – Needs Improvement
Problem understanding	Problem is clearly defined with strong justification and clear objectives.	Problem is mostly clear with minor gaps.	Problem is stated but lacks detail.	Problem is poorly defined or unclear.
Data and method	Data and methods are appropriate, sufficient and logically applied.	Data and methods are generally appropriate with minor omissions.	Limited data or basic methods.	Data is inadequate; methods missing or inappropriate.
Analysis	Analysis is thorough and interpretations are logically argued.	Analysis is sound with minor errors.	Analysis is partial or superficial.	Analysis is weak, incorrect or largely missing.
Recommendations	Recommendations are feasible and clearly derived from analysis.	Recommendations are relevant with minor limitations.	Recommendations are generic or loosely connected.	Recommendations are incomplete or absent.
Presentation	Work is well organized, neat and professionally presented.	Work is well organized with minor formatting issues.	Presentation is acceptable but uneven.	Work is poorly organized or difficult to follow.

URBAN GREEN INFRASTRUCTURE & NATURE-BASED SOLUTIONS			
Course Code	**1MCEE206D**	Scheme	2026
Type of Course	**PEC**	Semester	II
Teaching Hours/Week (L:T:P)	42(3:0:0)	CIE Marks	50
Total Hours of Pedagogy per semester L /T/P/SL&TW:	90(42:0:0:48)	SEE Marks	50
Credits	**3**	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

Course outcome (Course Skill Set)

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

1. CO1: Explain the principles, components and functions of urban green infrastructure (UGI) and nature-based solutions (NBS) in relation to urban resilience and sustainability.
2. CO2: Analyse urban environmental problems and select suitable blue-green infrastructure responses for mitigation and adaptation.
3. CO3: Apply planning, design and modelling concepts for UGI elements using basic technical guidelines and performance indicators.
4. CO4: Evaluate policy, governance, regulatory and financing mechanisms for implementation of NBS in urban projects.
5. CO5: Design context-specific UGI/NBS interventions with due consideration to ecological, social and economic factors.
6. CO6: Demonstrate familiarity with valuation, monitoring, case studies and performance assessment of UGI/NBS projects.

Module-1

Urbanization, Environmental Challenges and Urban Ecology:

- Global and Indian urbanization trends; implications for cities and urban growth patterns.
- Urban environmental stressors: pollution, flooding, heat islands, land degradation and waste accumulation.
- Sustainability and resilience concepts: meaning, interrelationship and relevance to urban systems.
- Fundamentals of urban ecology: urban ecosystems, structure and function, ecological interactions and ecosystem services.
- Biodiversity in cities: habitat fragmentation, native and invasive species, urban flora and fauna.
- Ecological footprints and carrying capacity: concept, urban resource demand and limits to growth.
- Introduction to Urban Green Infrastructure (UGI): definitions, evolution and need.
- Grey infrastructure versus green infrastructure: comparison, limitations and integration.
- Multi-functionality of UGI: environmental, social and economic benefits.
- Components of UGI: urban forests, street trees, parks, green belts, green corridors, green roofs, green walls and blue-green infrastructure systems.

Linked COs: CO1, CO2. **Number of Hours: 09**

Module-2

Blue-Green Infrastructure Components and Urban Water Systems:

- Blue-green infrastructure components and their role in urban resilience.
- Water Sensitive Urban Design (WSUD): concepts and applications.
- WSUD elements: rain gardens, bio-retention cells, bioswales and permeable pavements.
- Sustainable Drainage Systems (SuDS): principles and practice.
- SuDS elements: constructed wetlands, retention ponds and infiltration trenches.
- Vegetated infrastructure: green roofs, green walls/facades, urban forestry and street trees.
- Urban waterbodies management: riverine ecosystems, lakes and wetland restoration.
- Ecological and hydrological functions of blue-green systems in stormwater control and microclimate regulation.

Linked COs: CO2, CO3. **Number of Hours: 08**

Module-3

Planning, Design and Modelling:

- Landscape and recreation planning: ecological networks, green corridors and connected open spaces.
- Geoinformatics in NBS: GIS for mapping UGI, environmental planning and flood vulnerability assessment.
- Spatial analysis for identifying priority zones for UGI interventions.
- Participatory planning: citizen involvement in co-designing nature-based solutions for resilience.
- Stakeholder consultation methods and community-based planning approaches.
- Modelling tools: hydrologic and hydraulic modelling for blue infrastructure.
- Applications of modelling for runoff estimation, flood mitigation and performance assessment.
- Integration of planning, design and model outputs for site-specific NBS proposals.

Linked COs: CO3, CO5. **Number of Hours: 09**

Module-4

Implementation, Policy and Finance:

- Regulatory frameworks: environmental impact assessment for urban projects.
- Policy and governance: integrating NBS into city master plans and urban development strategies.
- Alignment with SDG 11: Sustainable Cities and Communities.
- Institutional roles and coordination among planning, municipal, environmental and development agencies.
- Finance models: private participation in green spaces through public-private partnerships.
- Risk management: socio-environmental risk assessment in urban infrastructure projects.
- Barriers to implementation and strategies for mainstreaming UGI in urban governance.
- Monitoring and compliance considerations for long-term performance.

Linked COs: CO4, CO6. **Number of Hours: 08**

Module-5

Economic Valuation and Case Studies:

- Valuation of ecosystem services provided by UGI and NBS.
- Cost-benefit analysis of nature-based solutions.
- Financing mechanisms: PPP, green bonds and related funding approaches.
- Life-cycle thinking in evaluating green infrastructure investments.
- Indian case studies: Bengaluru lakes, Chennai wetlands and Delhi Ridge.
- Global case studies: Singapore ABC Waters and Copenhagen cloudburst plan.
- Project presentations based on case analysis and local urban issues.
- Lessons learned from successful and failed implementations.

Linked COs: CO5, CO6. **Number of Hours: 08**

Suggested Learning Resources:

Textbooks:

1. Benedict, M.A. & McMahon, E.T., Green Infrastructure: Linking Landscapes and Communities, Island Press, 2006.
2. Kabisch, N. et al., Nature-Based Solutions to Climate Change Adaptation in Urban Areas, Springer, 2017.
3. Gill, S.E. et al., selected research papers on urban green infrastructure and climate resilience, various journals and conference proceedings.

Reference Books:

1. EPA Reports on Green Infrastructure, U.S. Environmental Protection Agency, latest editions/updated reports.
2. UNEP, World Bank, and IUCN reports on urban resilience, ecosystem services and nature-based solutions, latest editions/updated reports.

Web Links and e-Resources:

1. Urban Green Infrastructure: An Introduction – weADAPT
2. Nature-Based Solutions to Climate Change Adaptation in Urban Areas – SpringerOpen
3. Global mapping of urban nature-based solutions for climate change adaptation – Nature Sustainability
4. Evaluating Nature-based Solutions as urban resilience and climate adaptation tools – PubMed
5. Green Infrastructure for Stormwater Control – U.S. EPA
6. Resource Library – Australasian Green Infrastructure Network

7. UNEP Reports on Nature-Based Solutions and Urban Resilience
8. World Bank Urban Resilience Resources
9. IUCN Nature-Based Solutions Resources

Teaching-Learning Process (Innovative Delivery Methods):

- Flipped classroom.
- Problem-based learning.
- Case-based teaching.
- Simulation and software-based exercises.
- ICT-enabled teaching.
- Field data interpretation and mini-projects**.**

Suggested strategies:

- Problem-based learning on urban flooding, heat stress, lack of open space and ecosystem degradation.
- Case-based teaching using Indian and global examples of UGI/NBS implementation.
- GIS-based mapping and simple modelling exercises for site selection and impact assessment.
- Field visits to lakes, wetlands, parks, bioswales, green roofs and urban forest projects.
- Guest lectures by urban planners, environmental engineers, landscape architects and municipal officials.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of two Internal Assessment Tests (IA) shall be conducted. Each test shall be conducted for a maximum of 25 marks. The average of the two test marks shall be the marks secured by a student in IA.

In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks.

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 90 hours of study for 3 credit courses, which include Course instructions (CI-42 hour) and Teamwork/ Self learning (TW/Sl-48 hours). Hence, students must complete minimum of two actives as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The sample activities are given below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	TW1 – Site Assessment and Mapping Exercise: Conduct a neighbourhood/site assessment and map land use, drainage paths, imperviousness, tree cover and proposed UGI interventions. Linked COs: CO2, CO3.	24
2	TW2 – Design Concept and Maintenance Plan: Prepare a concept design for one NBS element such as a bioretention cell, green roof or street tree corridor, with species list, maintenance plan and monitoring indicators. Linked COs: CO3, CO5	24
3	TW3 – Case Study and Performance Review: Study a local urban lake, wetland or park and assess ecosystem services, constraints and improvement measures. Linked COs: CO4, CO6	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1	SL1 – Policy/Guideline Review: Read relevant municipal, state or international NBS guidelines and prepare a reflective note on their	24

	implications for practice. Linked COs: CO4, CO6	
2	SL2 – MOOC/Video Module on Urban Hydrology and Green Infrastructure: Complete an online course/module and submit a learning note. Linked COs: CO2, CO3	24
3	SL3 – Project Presentation: Prepare a short presentation on one Indian or global NBS case study, highlighting design, finance and outcomes. Linked COs: CO5, CO6.	24

Sample Rubrics for TW

Criterion	4 – Excellent	3 – Good	2 – Satisfactory	1 – Needs Improvement
Problem understanding	Problem is clearly defined with strong justification and clear objectives.	Problem is mostly clear with minor gaps in framing or justification.	Problem is stated but lacks clarity or detailed justification.	Problem is poorly defined or unclear.
Data and method	Data collected/used is appropriate and sufficient; methods/tools are well chosen and logically applied.	Data and methods are generally appropriate with minor issues or omissions.	Limited or partially relevant data; methods are basic or inconsistently applied.	Data is inadequate/irrelevant; methods are inappropriate or missing.
Analysis	Analysis is thorough; interpretations are logically argued and results are valid.	Analysis is generally sound with minor errors or missing details.	Analysis is partial; contains gaps or superficial interpretation.	Analysis is weak, incorrect or largely missing.
Recommendations	Recommendations are feasible, context-specific and clearly derived from analysis.	Recommendations are relevant but may have minor limitations or lack detail.	Recommendations are generic or only loosely connected to analysis.	Recommendations are incomplete, unrealistic or absent.
Presentation	Work is very well organized, neat and professionally presented.	Work is well organized with minor issues in formatting or clarity.	Presentation is acceptable but uneven; structure or formatting needs improvement.	Work is poorly organized, difficult to follow or untidy.

AIR QUALITY AND SOLID WASTE MANAGEMENT LABORATORY			
Course Code	**1MCEEL207**	Scheme	2026
Type of course	Professional Core Course Lab	Semester	II
Teaching Hours/Week (L:T:P)	2(0: 0: 2)	CIE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	30(0: 0:28:2)	SEE Marks	50
Credits	1	Total Marks	100
Type of Examination	**Practical**	Exam Hours	3

Course outcome (Course Skill Set)

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

1. CO1: Determine ambient air quality parameters and interpret compliance with prescribed standards.
2. CO2: Analyze air pollutant sampling data and identify major sources and control measures.
3. CO3: Characterize solid waste and evaluate segregation, storage, collection, and transportation systems.
4. CO4: Design simple material recovery, composting, and sanitary disposal strategies for municipal solid waste.
5. CO5: Apply safety, sustainability, and regulatory principles in environmental laboratory investigations.

Note:

1. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6-8 conventional experiments, PART-B has 6 typical open-ended experiments. The maximum marks for the laboratory course are 100.
2. Both PART-A and PART-B are considered for CIE and SEE.
3. Students have answer 1(one) question from PART-A and 1(one) question from PART-B.
   a. The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for **80 marks** out of the maximum 100 marks.
   b. The open-ended question set for SEE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for **20 marks.**

For Continuous Internal Evaluation (CIE) during the semester, classwork shall typically include open-ended questions from **Part-B**, along with other similar questions designed to enhance the students' skills.

PART – A

FIXED EXPERIMENTS

1. Determination of PM2.5 and PM10 in ambient air using a portable air quality monitoring instrument. (CO1, CO2)
2. Measurement of particulate matter concentration using gravimetric method with filter paper and air sampler. (CO1)
3. Estimation of carbon monoxide / sulfur dioxide / oxides of nitrogen using available laboratory or field instruments. (CO1, CO2)
4. Measurement of noise levels in a selected campus location and preparation of noise contour interpretation. (CO1, CO2)
5. Characterization of municipal solid waste: physical composition, moisture content and Density.
6. Determination of Calorific value of solid wastes using Bomb calorimetric instrument. (CO3)
7. Segregation and assessment of biodegradable, recyclable, and inert fractions from mixed municipal waste. (CO3, CO5)
8. Design and demonstration of composting / vermicomposting process for biodegradable solid waste. (CO4)
9. Study of collection, storage, transfer station, and transportation system for municipal solid waste using a case study. (CO3, CO4)

PART – B

OPEN ENDED EXPERIMENTS

Open-ended experiments are a type of laboratory activity where the outcome is not predetermined and students are given the freedom to explore, design, and conduct the experiment based on the problem statements as per the concepts defined by the course coordinator. It encourages creativity, critical thinking, and inquiry-based learning.

1. Prepare an air quality assessment plan for a busy intersection and recommend control measures. (CO1, CO2)
2. Analyze seasonal variation in PM levels from field data and propose source-specific mitigation. (CO1, CO2)
3. Develop a small-scale municipal solid waste segregation model for a residential campus or hostel. (CO3, CO5)
4. Propose a decentralized composting system for biodegradable waste generated in the institution. (CO4)
5. Design a material recovery workflow for paper, plastic, metal, and glass fractions. (CO3, CO4)
6. Assess the environmental and operational performance of different solid waste collection routes and suggest optimization. (CO3, CO5)

Suggested Resources:

Textbooks

1. C. S. Rao, *Environmental Pollution Control Engineering*.
2. H. S. Peavy, D. R. Rowe, and G. Tchobanoglous, *Environmental Engineering*.
3. G. Tchobanoglous, H. Theisen, and S. A. Vigil, *Integrated Solid Waste Management*.
4. A. D. Bhide and B. B. Sundaresan, *Solid Waste Management in Developing Countries*.

Reference books

1. Charles A. Wentz, *Hazardous Waste Management*.
2. F. Flintoff, *Management of Solid Wastes in Developing Countries*.
3. M. N. Rao and A. K. Datta, *Wastewater Treatment*
4. Y. Anjaneyulu, *Textbook of Air Pollution and Control Technologies*.
5. Arcadio P. Sincero and Gregoria A. Sincero, *Environmental Engineering: A Design Approach*.

Web resources

1. Central Pollution Control Board, *Solid Waste Management Rules, 2016*.
2. CPCB, *About National Air Quality Index*.
3. CPCB, *Guidelines for Ambient Air Quality Monitoring*.
4. CPCB publication pages and manuals on air, noise, and waste management for updated circulars and practical guidance.
5. MoHUA and CPCB documents on municipal solid waste systems and implementation aspects.

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be 50% each. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of 40% of the maximum marks prescribed for SEE to be eligible for a pass in the course.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject /course only if he/she secures not less than 50% of the aggregate marks obtained in CIE and SEE taken together.

Continuous Internal Evaluation (CIE):

For the Professional Core Course Laboratory, the maximum marks prescribed are 100. Out of these, 50 marks are allotted for Continuous Internal Evaluation (CIE) and 100 marks for the Semester End Examination (SEE). The SEE marks obtained out of 100 shall be proportionately scaled down to 50 marks. The final result shall be declared based on the aggregate of the CIE marks (50) and the scaled-down SEE marks (50), totalling 100 marks."

Out of 50 marks, 40 marks shall be assigned for assessment of regular laboratory PART -A classwork, and 10 marks for Part – B. (Table 1)
Out of 40 marks, 25 marks shall be based on the regular classwork and allotment of marks shall be as per rubrics listed in Table 1.
The remaining 15 marks shall be based on the practical test conducted by two Internal examiners appointed by the HoD. The allotment of marks shall be as per the rubrics defined for the practical test as indicated in the Table 1.
The open-ended question set for CIE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for 10 marks. The allotment of marks shall be as per rubrics listed in Table 2.

Table – 1 Distribution of marks corresponding to laboratory component

Component	Description	Marks
Allotment of marks for regular classwork		
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	10 marks
Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission.	15 marks
	Subtotal	**25**
Allotment of marks for CIE practical test		
Laboratory Test / Experiment Performance	Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment.	5 marks
Viva-Voce	Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions.	10marks
	Subtotal	**15**
	Total	**40**

Table 2 Distribution of marks corresponding to PART -B of the laboratory component

Evaluation Rubrics for continuous internal evaluation CIE). Maximum marks:10

Criteria and Guiding factors	Students' Level and Rubrics Excellent: E, Good: G, Fair: F Needs Improvements: NI			
	E	G	F	NI
(1) Problem Understanding **Criteria:** Is the problem understood correctly and framed appropriately? (i)Clarity in interpreting the given problem. (ii)Identification of relevant concepts and constraints. (iii) Ability to rephrase or model the problem logically.	2.0	1.5	1.0	0.5
(2) Conceptual Knowledge **Criteria**: Are the chosen methods or concepts valid for this type of problem? (i)Application of appropriate theories, principles, or laws. (ii)Integration of multiple concepts where necessary. (iii)Accuracy in stating relevant equations or models.	2.0	1.5	1.0	0.5

(3) Approach and Strategy **Criteria**: Is the approach well thought out and methodical? (i)Logical structure and progression. (ii)Use of diagrams, sketches, or flowcharts if applicable. (iii)Identification of assumptions and boundary conditions.	2.0	1.5	1.0	0.5
(4) Execution and Accuracy **Criteria**: Are the calculations correct? Is the final solution reasonable? (i) Correct application of formulas/methods. (ii)Accuracy of calculations or simulations (if any). (iii)Unit consistency and result verification.	2.0	1.5	1.0	0.5
(5) Innovation or Depth **Criteria**: Has the student shown original thinking or alternative methods? (i)Novel or efficient solutions. (ii)Consideration of alternate approaches. (iii)Interdisciplinary integration or practical extensions.	1	0.75	0.5	0.25
(6) Presentation and Clarity **Criteria**: Is the answer easy to follow and professionally written? (i)Organization and neatness. (ii)Clarity of explanation, labelling, and steps. (iii) Use of proper technical terminology.	1	0.75	0.5	0.25
Total	10	7.5	5.0	2.5

Note:
(i)The marks shown for Excellent, Good, Fair, Needs Improvement are indicative. The evaluator may also assign intermediate scores depending on the quality of work.
(ii)If the total score results in a fraction, it should be rounded off to the next higher integer.
(iii)The listed criteria are guidelines; evaluators may also consider other authentic dimensions (e.g., depth of insight, critical thinking, and practical awareness, recognition of limitations, or justified compromises.
(iv)To award the full10 marks in the excellent category, the student must demonstrate reasonably good performance across all six criteria; otherwise, proportionally lower marks may be given.

****