Department of Civil and Environmental Engineering
Birla Institute of Technology, Mesra, Ranchi - 835215 (India)

Institute Vision

- To become a Globally Recognized Academic Institution in consonance with the social, economic and ecological environment, striving continuously for excellence in education, research and technological service to the National needs.

Institute Mission

- To educate students at Undergraduate, Post Graduate Doctoral and Post-Doctoral levels to perform challenging engineering and managerial jobs in industry.
- To provide excellent research and development facilities to take up PhD programmes and research projects.
- To develop effective teaching and learning skills and state of art research potential of the faculty.
- To build national capabilities in technology, education and research in emerging areas.
- To provide excellent technological services to satisfy the requirements of the industry and overall academic needs of society.

Department Vision

- To develop quality intellectuals through education, research and motivation so that they can bring a positive contribution to the society in area of Civil and Environmental Engineering

Department Mission

- To develop professional skills through quality education & research.
- To outreach various sectors of society through interdisciplinary programmes and practical oriented approach.
- To create dynamic, logical and effective leaders with inspiring mindsets.

PEOs and POs for M.Sc. (Environmental Science and Technology)

Programme Educational Objectives (PEOs)

PEO1: Graduates will demonstrate a strong foundation in environmental science and engineering principles, enabling them to pursue successful careers in industry, academia, research, and consultancy.

PEO2: Graduates will be able to identify, formulate, and solve complex environmental problems using modern tools, analytical skills, and interdisciplinary knowledge.

PEO3: Graduates will develop and implement sustainable and practical solutions to address challenges in diverse ecosystems and environmental systems.

PEO4: Graduates will exhibit ethical responsibility, social awareness, and a commitment to environmental stewardship in their professional practices and community engagements.

PROGRAMME OUTCOMES (POs)

PO1: Demonstrate the ability to independently conduct investigations and apply scientific methods to solve complex ecological and environmental problems.

PO2: Exhibit a broad range of skills and professional competencies in environmental science, technology, and sustainability practices.

PO3: Attain advanced knowledge and technical expertise in the Environmental Science and Technology, exceeding the proficiency expected at the undergraduate level.

PO4: Develop and implement comprehensive environmental impact assessments, monitoring strategies, and environmental management plans.

PO5: Effectively communicate scientific information through high-quality reports, research articles, and technical documentation.

PO6: Critically evaluate issues related to environmental sustainability, social governance, engage and sensitize communities, and assess alternative solutions to support informed and responsible decision-making in environmental science.

Course Curriculum for M.Sc. (Environmental Science and Technology)

Semester I

	Course Level	Course Code	Course Name	Delivery MET25-hod Lecture – L; Tutorial – T; Practical - P			Credits
				L	T	P	
Semester I	Program Core	MET25-501	Ecology and Biodiversity	3	0	0	3
	Program Core	MET25-502	Environmental Chemistry and Microbiology	3	0	0	3
	Program Core	MET25-503	Water and Wastewater Treatment	3	0	0	3
	Program Core	MET25-504	Environmental Impact Assessment, Laws and ISO Standards	3	0	0	3
	Open Elective	MET25- 505	OE I/MOOC	3	0	0	3
	Program Core	MET25-506	Ecology and Biodiversity Laboratory	0	0	4	2
	Program Core	MET25-507	Water and Wastewater Analysis Laboratory	0	0	4	2
	Mandatory Course	MT 132	Communication Skills I	0	0	3	1.5
	Total Credits						**20.5**

Semester II

	Course Level	Course Code	Course Name	Delivery MET25-hod Lecture – L; Tutorial – T; Practical - P			Credits
				L	T	P	
Semester II	Program Core	MET25-508	Occupational Health and Industrial Safety	3	0	0	3
	Program Core	MET25-509	Soil Pollution and Solid Waste Management	3	0	0	3
	Program Core	MET25-510	Air Pollution and Global Climate Change	3	0	0	3
	Program Core	MET25-511	Application of Remote Sensing in Environment	3	0	0	3
	Program Core	MET25-512	Sustainability and Environmental Social Governance	3	0	0	3
	Program Core	MET25-513	Air & Soil Laboratory	0	0	4	2

	Program Core	MET25-514	Remote Sensing Laboratory	**0**	**0**	**4**	**2**
	Open Elective	MT133	Communication Skills II	**0**	**0**	**3**	**1.5**
	Total Credits						**20.5**

Semester III

Semester III	**Course Level**	**Course Code**	**Course Name**	**Delivery MET25-hod Lecture – L; Tutorial – T; Practical - P**			**Credits**
				L	**T**	**P**	
	Program Core	MET25- 516	Earth Science and Energy Resources	**3**	**0**	**0**	**3**
	Program Elective	MET25- 517	PEI	**3**	**0**	**0**	**3**
	Program Elective	MET25- 518	PE II	**3**	**0**	**0**	**3**
	Program Core	MET25- 519	Project Part I				**7**
			Viva				**1**
	Mandatory Course	MET25-520	Industrial Training/Internship in Reputed Institute (Mandatory)*	0	0	0	2
	Total Credits						**19**
	***During summer vacation, students should attend the training /internship**						

Semester IV

Semester IV	**Course LMET25-el**	**Course Code**	**Course Name**	**Delivery MET25-hod Lecture – L; Tutorial – T; Practical - P**			**Credits**
				L	**T**	**P**	
	Program Core	MET25- 521	Project Part II	**0**	**0**	**20**	**20**
	Total Credits						**20**

Grand Total of Credits: (41+39=80)

Program Electives:

MET25-522 Environmental Economics
MET25-523 Environmental Toxicology
MET25-524 Environmental Statistics and Optimisation
MET25-525 Instrumental Method for Analysis of Environmental Samples
MET25-526 Disaster Management
MET25-527 Advanced Water & Wastewater Treatment
MET25-528 Industrial Pollution Control
MET25-529 Environmental Biotechnology
MET25-530 Natural Resource Management

FIRST SEMESTER

COURSE INFORMATION SHEET

Course code	**:**	**MET25501**
Course title	**:**	**Ecology and Biodiversity**
Pre-requisite(s)	**:**	**B.Sc.**
Co-requisite	**:**	**-**
Credits	**:**	**3 (L:3 T:0 P:0)**
Class schedule per week	**:**	**3**
Class	**:**	**M.Sc.**
Semester / Level	**:**	**I/5**
Branch	**:**	**Environmental Science & Technology**
Name of Teacher	**:**	

Course objectives

This course enables the students to:

1	To develop a comprehensive understanding of the structural and functional attributes of ecosystems and the environment
2	To build awareness of the impacts of climate change and pollution on natural resources, including biodiversity
3	To enable students to critically analyze ecological principles and apply them toward achieving sustainable development goals

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Conceptualize the structure and function of ecosystems and determine ecosystem characteristics through field-based assessments
CO2	Analyze population dynamics, including growth patterns, species interactions, and the influence of environmental factors
CO3	Evaluate the structure, function, and interactions within ecological communities
CO4	Assess the significance, methods of measurement, and strategies for the conservation of biodiversity across diverse ecosystems
CO5	Apply ecological principles to address environmental challenges and promote sustainable development practices

MET25501: **Ecology and Biodiversity**

Module I

Introduction to Ecology and Evolutionary Concepts

Definition, Scope, and Branches of Ecology, Levels of Organization: Individual to Biosphere, Concept and Structure of Ecosystems: Producers, Consumers, Decomposers; Trophic Levels and Interconnectedness (e.g., Gaia Hypothesis); Classification of Ecosystems: Natural and Artificial, Terrestrial and Aquatic,

Module II: Abiotic Environment and Energetics

Ecological Laws: Liebig's Law of Minimum, Law of Tolerance, Limiting Factors

Energy in Ecological Systems: Solar Radiation, Primary and Secondary Productivity, Laws of Thermodynamics in Ecology, Food Chains, Food Webs, and Ecological Pyramids (Energy, Biomass, Numbers), Concepts of Energy, Exergy, Ascendency, and Ecological Footprint

Ecological Efficiency, Models of Energy Flow (Single channel and Y-shaped models); Ecosystem Homeostasis and Stability

Module III

Biogeochemical Cycles and Energy Flow

Overview and Importance of Biogeochemical Cycles, Major Cycles: Hydrological, Carbon, Nitrogen, Sulphur, Phosphorus; Bioaccumulation, Biotransformation, Biomagnification, Bioconcentration factor, Translocation factor.

Module IV

Population and Community Ecology

Population Ecology: Characteristics: Density, Natality, Mortality, Age Structure; Growth Models: Exponential and Logistic; Population Regulation Mechanisms; r/K Selection, Niche Concept; Community Ecology: Community Structure: Stratification, Dominance, Diversity, Species Interactions: Interspecific (Predation, Competition, Parasitism) and Intraspecific Ecological Succession: Types, Mechanisms, Climax Communities

Module V

Biodiversity and Conservation Ecology

Definition, Types, and Levels of Biodiversity, Methods of Measuring Biodiversity: Indices,, Causes and Consequences of Biodiversity Loss; Conservation Strategies: In Situ (National Parks, Sanctuaries, Biosphere Reserves), Ex Situ (Seed Banks, Zoos, Botanical Gardens); Biodiversity Management and Policy Frameworks: Indian Initiatives (NBA, BSI, ZSI, Biodiversity Act), Global Conventions (CBD, CITES, Ramsar, IUCN, IPBES); Role of Biodiversity Registers, Bioprospecting, and Issues of Biopiracy.

Books Recommended:

TEXTBOOK

1. Fundamentals of Ecology (3rd ed.) - Eugene P. Odum. WB Sunders Company, Philadelphia, 1971 (T1)
2. Ecology and environment – P. D. Sharma (T2)
3. Fundamentals of Ecology- MC Dash, Tata - McGraw Hill, New Delhi, 1996. (T3)
4. Introduction to Environmental Engg. - GM Masters, Prentice Hall of India, 1991. (T4)
5. Biodiversity and Conservation - P. C. Joshi (T5)
6. A Textbook of Environmental Science -Prabhat Patnaik 6. A Textbook of Environmental Sciences-Purohit (T6)

REFERENCE BOOK

1. Microbiology for Environmental Scientists and Engineers – AF Gaudy (R1)
2. Enzymatic Transformation of Metals - Strains for Enhanced Biodegradation - Improved Biodegradation by Protein. T Gaudy, McGraw-Hill, New York, 1980. (R2)
3. Elements of Ecology (6^{th} edition) – Thomas M. Smith and Robert Leo Smith, Pearson Education, 2007. (R3)
4. Biodiversity and Conservation - M. P. Singh and Aravind Kumar (R4)

Gaps in the syllabus (to meet Industry/Profession requirements)

Application of real life industrial problems

POs met through Gaps in the Syllabus: PO5 and PO6

Topics beyond syllabus/Advanced topics/Design:

Application for real life problems arising in industries through lab-based experiments

POs met through Topics beyond syllabus/Advanced topics/Design: **PO5 and PO6**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS AND EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 (3 X 10)
Assignment(s)	10
Seminar before a Committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	2	1	3
CO2	3	3	3	3	1	2
CO3	3	1	3	3	1	2
CO4	3	2	3	3	3	3
CO5	3	2	3	2	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2
CO2	CD1, CD2, CD4, CD5

COURSE INFORMATION SHEET

Course code : MET25502
Course title: Environmental Chemistry and Microbiology
Pre-requisite(s) : B.Sc.
Co-requisite : -
Credits : 3 (L:3 T:0 P:0)
Class schedule per week : 3
Class : M.Sc.
Semester / Level: I/5
Branch : Environmental Science & Technology
Name of Teacher :

Course Objectives:
This course enables students to

1	Describe the fundamentals of environmental chemistry and microbiology
2	Explain the concepts related to chemical and microbial processes in the atmosphere, aquatic systems and soil.
3	Develop environmental monitoring and assessment programs for environmental quality monitoring and pollution control.

Course Outcomes:
After the completion of this course, students will be able to

1	Apply the fundamentals of environmental chemistry and microbiology, which are important for practising environmental science and technology.
2	Interpret the chemistry of air, soil and water pollution, enabling them to work on its treatment.
3	Design and carry out environmental quality management projects.

Syllabus

Module I **[8 Lectures]**
Basics of environmental chemistry: Units of measurement, mass balance, enthalpy, chemical equilibria, chemical kinetics, and Chemical thermodynamics - work done, internal energy, enthalpy, entropy, Gibbs free energy, specific heat, environmental transformation, and degradation processes.

Module II **[8 Lectures]**
Atmospheric and aquatic Chemistry:
Atmosphere – structure & composition, reactions and calculations in atmospheric chemistry, solubility of gases in water, chemistry of troposphere – particulate matter, hydrocarbons, CO, oxides of sulfur, oxides of nitrogen, chemistry of stratosphere.
Physico-chemical properties of water, organic components in natural waters, estuarine and ocean chemistry, water pollution – deoxygenation, DO & BOD, eutrophication, Eh-pH diagram, chemicals speciation.

Module III **[8 Lectures]**

Soil Chemistry and environmental sample analysis: Soil formation, soil reactions - acid-base, redox, chelation, soil organic matter, soil properties, soil acidity, soil salinity and sodicity, acid sulphate soil. Sampling of water, wastewater, soil and sediments, environmental samples analysis - gravimetric and volumetric methods, spectroscopic techniques, and chromatographic techniques.

Module IV **[8 Lectures]**

Introduction to environmental microbiology:

Classification and characterization of microorganisms, Morphology and structure of bacteria, nutritional requirement, growth of bacteria; Basic microbiology of water and sewage

Module V **[8 Lectures]**

Microbes in waste treatment:

Aerobic and anaerobic metabolism, kinetics of microbial growth, role of microbes in biological waste treatment - bioremediation, biodegradation, wastewater treatment, biological nutrient removal.

Books Recommended:

Textbook:

1. Environmental Chemistry - A global perspective, Gary W. Van Loon and Stephen J. Duffy, Oxford University Press
2. Introduction to Environmental Engineering and Science, G.M. Masters & Wendell Ela, PHI Publishers
3. Microbiology, Michael Pelczar Jr., ECS Chan, NR Kreig, Tata McGraw-Hill Education
4. Wastewater Engineering: Treatment and Reuse, Metcalf & Eddy, McGraw-Hill Publishers

Reference Books:

1. Environmental Chemistry, Stanley Manahan, Stanley E. Manahan, CRC Press.
2. Chemistry for Environmental Engineering, Clair N. Sawyer, Perry McCarty, Gene F. Parkin, McGraw Hill Inc. New York.
3. Basic Concepts of Environmental Chemistry, DW Conell, CRC Press
4. Standard Methods of Testing of Water and Wastewater" APHA, AWWA, & WPCF
5. Environmental Chemistry – a global perspective. Gary W. Vanloon and Stephen J. Duffy
6. Brock Biology of Microorganisms, Michael T. Madigan, John M. Martinko, Kelly S. Bender, Daniel H. Buckley, David A. Stahl, Thomas Brock

Gaps in the syllabus (to meet Industry/Profession requirements)

Design of real-time industrial projects.

POs met through Gaps in the Syllabus: PO4, PO5 & PO6.

Topics beyond syllabus/Advanced topics/Design

Course Delivery Methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training
Self-learning, such as the use of NPTEL materials and the internet
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure
Direct Assessment

Assessment Tool	**% Contribution during CO Assessment**
Continuous Internal Assessment	50
End Sem Examination	50

Indirect Assessment:
1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes
Mapping of Course Outcomes into Program Outcomes

Course Outcomes	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	2	3	1	1
CO2	3	2	3	3	1	1
CO3	3	3	2	3	1	1

Mapping Between COs and Course Delivery (CD) Methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO 1, 2, 3	CD1, CD2
CD2	Tutorials/Assignments		CO 1, 2, 3	CD1, CD2
CD3	Seminars		CO 1, 2, 3	CD1, CD2, CD3
CD4	Mini projects/Projects			
CD5	Laboratory experiments/teaching aids			
CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self-learning, such as the use of NPTEL materials and the internet			
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: MET25503
Course title: Water and Wastewater Treatment
Pre-requisite(s): B.Sc.
Co-requisite: -
Credits: 3 (L:3 T:0 P:0)
Class schedule per week: 3
Class: M.Sc.
Semester / Level: I/5
Branch: Environmental Science and Technology
Name of Teacher:

Course Objectives:
This course enables the students:

1.	To understand the basic concept of water supply
2.	To characterise and classify the water quality
3.	To understand different water treatment techniques
4.	To understand the basic concepts of wastewater treatment
5.	To understand the wastewater treatment units and their application

Course Outcomes:
After the completion of this course, students will be:

1.	Able to assess the water quality and its sources for different water supply schemes
2.	Able to calculate water demand for upcoming or existing establishments over time
3.	Able to understand the existing treatment units and recommend the modern technologies required to meet new standards
4.	Able to understand and apply the basics of wastewater treatment methods
5	Able to evaluate the influence of the different parameters in the design and treatment of a wastewater treatment plant

Syllabus

Module I **[8 Lectures]**
Water quality: Physical, chemical, Bacteriological characteristics, water quality standards. Basics of water supply: Design Period, Population Forecast, Factors affecting population growth, Water Demand.

Module II **[8 Lectures]**
Sources of water and their transportation: Hydrological cycle, Rainfall and runoff, groundwater sources, Surface sources, intake structures and conduits, and Pumps.

Module III **[8 Lectures]**
Water treatment units: aeration, sedimentation, coagulation, flocculation, filtration, disinfection, adsorption, water softening, reverse osmosis.

Water distribution network, service reservoirs, water supply appurtenances, and smart water systems.

Module IV **[8 Lectures]**

Basics of wastewater: Quality of sewage, sewage estimation, stormwater estimation, Flow of sewage, Hydraulic considerations of sewage conveyance.

Module V **[8 Lectures]**

Sewage treatment: preliminary, Primary, Secondary, and Tertiary treatment. Aerobic treatment processes: attached and suspended growth processes. Anaerobic treatment processes: suspended and attached growth. Solids and residuals management: sludge treatment processes, sludge utilization

Books Recommended:

Textbooks:

1. Garg, S. K. (2007) Water supply engineering, 18th ed, Vol. I. New Delhi: Khanna Publisher.
2. Chatterjee, A. K.2010.Water supply, Waste disposal and environmental Engineering, 8th ed. New Delhi: Khanna Publisher.
3. CPHEEO 1999. Manual on Water supply and treatment. 3rd Edition
4. Nathanson, Jerry A. (2009) Basic environmental technology: water supply, waste management and pollution control, 4th ed. New Delhi: PHI Learning.
5. Chatterjee, A. K.2010.Water supply, Waste disposal and environmental Engineering, 8th ed. New Delhi: Khanna Publisher.
6. Metcalf & Eddy (2003) Wastewater engineering: treatment and reuse, 4th ed. New Delhi: Tata McGraw-Hill.

Reference books:

1. American Water Works Association, Manual, AWWA
2. Qasim, Syed R., Motley, Edward M., and Zhu, Guang (2000) Water works engineering: planning, design and operation. New Jersey: Prentice Hall.
3. Nathanson, Jerry A. (2009) Basic environmental technology: water supply, waste management and pollution control, 4th ed. New Delhi: PHI Learning.
4. Garg, S.K. (2007) Sewage disposal and air pollution engineering, 20th ed, Vol. II. New Delhi: Khanna Publisher.
5. Chatterjee, A. K.2010.Water supply, Waste disposal and Environmental Engineering, 8th ed. New Delhi: Khanna Publisher.
6. CPHEEO Manual on Sewerage and Sewage Treatment, latest edition

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus. PO4, PO5 & PO6

Topics beyond the syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design.

Course Delivery methods
Lectures by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training
Self, learning such as the use of NPTEL materials and the internet
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Quiz Marks	30
Assignment	10
Seminar	10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Quiz Marks	3	3	3	3	3
End Sem Examination Marks	3	3	3	3	3
Assignment	3	3	3	3	3

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Mapping of Course Outcomes into Program Outcomes

Course Outcome	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
1	3	1	3	3	1	1
2	3	1	3	3	1	1
3	3	3	3	3	1	1
4	3	1	3	3	1	1
5	3	1	3	3	1	1

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery Methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lectures by use of boards/LCD projectors/OHP projectors		CO1, 2, 3, 4, 5	CD1
CD2	Tutorials/Assignments		CO 2, 3, 4, 5	CD1
CD3	Seminars		CO 2, 5	CD1 and CD2
CD4	Mini projects/Projects			CD1 and CD2
CD5	Laboratory experiments/teaching aids			CD1 and CD2
CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

COURSE INFORMATION SHEET

Course Code: MET25- 504 Course Title: Environmental Impact Assessment, Laws and ISO standards
Pre-requisite(s): B.Sc.
Co-requisite: -
Credits : 3 (L:3 T:0 P:0)
Class schedule per week: 3
Class: M.Sc.
Semester / Level : III/5
Branch: Environmental Science & Technology
Name of Teacher :

Course Objectives
This course enables the students:

1	To provide an overview on international conventions, and laws and ISO systems for sustainable environment
2	To develop a basic understanding on the process of environmental impact assessment, laws, ISO standards
3	To understand the components of environmental reports and management plans

Course Outcomes
After the completion of this course, students will be able to:

CO1: Explain the principles, processes, and importance of EIA in project planning and decision-making and Develop Environmental Management Plans (EMPs) and monitoring strategies.
CO2: Identify and apply appropriate EIA methodologies for different environmental components.
CO3: Analyze and interpret national and international environmental laws and policies.
CO4: Understand and apply ISO 14001 and related standards for environmental management systems.

SYLLABUS

Module I: [8 Lectures]
Introduction to Environmental Impact Assessment
Definition, scope, objectives, and need for EIA, Historical development and legal mandate of EIA in India, Types and classification of EIA (strategic, rapid, comprehensive), EIA process and life-cycle assessment

Module II: [8 Lectures]
EIA Methodologies and Tools
Screening, scoping, baseline data collection, Impact prediction and evaluation (air, water, land, noise, socio-economic, biological), Checklists, matrices, overlays, network methods, GIS-based methods, Public participation and stakeholder consultation, Preparation of Environmental Management Plan (EMP) and mitigation strategies.

Module III: **[8 Lectures]**

Environmental Clearance and Monitoring

EIA Notification 2006 and amendments, Categorization of projects (Category A & B), Role of Expert Appraisal Committee (EAC), SEAC, Post-clearance monitoring, compliance, and auditing

Module IV: **[8 Lectures]**

Environmental Legislation and Governance

Overview of Indian environmental laws:
Environment Protection Act, 1986, Air (Prevention and Control of Pollution) Act, 1981, Water (Prevention and Control of Pollution) Act, 1974, Forest Conservation Act, 1980, Wildlife Protection Act, 1972, Role of Central and State Pollution Control Boards, International conventions: Stockholm, Rio, Kyoto, Paris Agreement

Module V:

[8 Lectures]

Environmental Management Standards and ISO

Concepts of Environmental auditing, Introduction to ISO and environmental management, ISO 14000 family of standards (with focus on ISO 14001:2015), EMS planning, implementation, auditing, and certification, Life Cycle Assessment (LCA) and Environmental Product Declarations (EPD), eco-labels, Case study

Books recommended:

TEXTBOOKS:

1. Environmental Impact Assessment: Larry Canter. McGraw Hill Publication.
2. Disaster Management- Edited by R. B. Singh. Rawat Publications. India.
3. Environmental Impact Assessment- A. K. Shrivastava. APH Pub. India.
4. Environmental Impact Assessment. Theory and Practice. Anji Reddy Mareddy, 1st Edition, eBook ISBN: 9780128112380, Paperback ISBN: 9780128111390, Butterworth-Heinemann.
5. Environmental Audit: A.K.Shrivastava. APH pub Corp. New Delhi.
6. ISO 14000: Environmental Management 1st Edition, David L. Goetsch
7. Stanley Davis. ISBN-13: 978-0130812360. Jenson Books Inc
8. Bhatia, H.S. (2021). *Environmental Law and Management*. Oxford Book Company.
9. UNEP (United Nations Environment Programme): EIA Training Resource Manual
10. ISO 14001:2015 Standard Document (Available from ISO website)

REFERENCE BOOKS:

1. Methods of Environmental Impact Assessment, Graham Wood, Riki Therivel. ISBN-13: 978-1138647671. Routledge; 4 editions.
2. Global Green standards: ISO 14000 and Sustainable Development. IISD pub. Minitoba.
3. ISO 14000 Answer Book: Environmental Management for the World Market (Wiley Quality Management) 1st Edition. by Dennis R. Sasseville W. Gary Wilson, Robert

W. Lawson . ISBN-13: 978-0471179337. John Wiley and sons. Canada.

Gaps in the syllabus (to meet Industry/Profession requirements) :
Syllabus is framed according to industrial and professional requirement.

Topics beyond syllabus/Advanced topics/Design:
Module 4 covers review of DPRs that will be allow the students to learn and write project reports that require EIA.
POs met through Topics beyond syllabus/Advanced topics/Design: **PO2**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS AND EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 (3 X 10)
Assignment(s)	10
Seminar before a Committee	10

Assessment Components	CO1	CO2	CO3	CO4
Continuous Internal Assessment	✓	✓	✓	✓
Semester End Examination	✓	✓	✓	✓

Indirect Assessment:

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO 2	PO3	PO4	PO5	PO6
CO 1	3	2	3	3	3	3
CO 2	3	3	2	3	3	3
CO 3	2	3	3	1	3	3
CO 4	2	3	0	1	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcome	**Course Delivery Method**
CO1	CD1, CD2
CO2	CD1, CD2
CO3	CD1, CD2, CD8, CD6
CO4	CD1, CD2, CD3

COURSE INFORMATION SHEET

Course code	**:**	**MET 25506**
Course title	**:**	**Ecology and Biodiversity Laboratory**
Pre-requisite(s)	**:**	**B.Sc.**
Co-requisite	**:**	**-**
Credits	**:**	**2 (L:0 T:0 P:4)**
Class schedule per week	**:**	**4**
Class	**:**	**M.Sc.**
Semester / Level	**:**	**I/5**
Branch	**:**	**Environmental Science & Technology**
Name of Teacher	**:**	

Course objectives:

This course enables the students to:

1	To provide hands-on experience collecting, analyzing, and interpreting ecological and biodiversity data through fieldwork and laboratory experiments.
2	To develop skills using various tools and techniques for assessing species diversity, population dynamics, and ecosystem health.

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Effectively collect and record ecological and biodiversity data using field and laboratory techniques.
CO2	Identify and classify various species within different ecosystems accurately.
CO3	Design and conduct ecological experiments, including hypothesis formation, data collection, and statistical analysis.
CO4	Demonstrate the ability to analyze ecological data and interpret results to understand population dynamics and community structures.
CO5	Gain proficiency in using ecological tools and software for biodiversity assessment and data analysis.

Syllabus

List of Experiments

1. To estimate the minimum size of quadrats required for plant community study
2. To estimate the minimum number of quadrats required for plant community study
3. Transect Line Sampling for Animal Populations
4. Determination of Importance Value Index of plant species
5. Species Richness and Evenness in Different Habitats
6. Productivity analysis of terrestrial plants
7. Productivity analysis of aquatic ecosystem
8. Microbial Diversity in Different Soil Types
9. Bird Diversity and Abundance in Different Habitats
10. Leaf Litter Decomposition Study

Books recommended:

1. "Ecology and Environment" by P.D. Sharma
2. "Ecology of Tropical Savannas" by J.S. Singh
3. "Experimental Ecology: Issues and Perspectives" by K. Sankaran Unni

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:
Local ecology and biodiversity study
POs met through Topics beyond syllabus/Advanced topics/Design: **Through biodiversity and ecological surveys**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS AND EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Progressive evaluation	60
Semester End Examination	40

Continuous Internal Assessment	% Distribution
Day-to-day performance and Lab files	30
Quiz	15
Viva	15

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment
1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery methods

CD1	Instruction by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments
CD4	Guest lectures
CD5	Visit to different ecosystems
CD6	Self- learning such as use of NPTEL materials and internets

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	1	1	1
CO2	3	2	3	1	1	1
CO3	3	2	3	1	1	1
CO4	3	2	3	1	1	2
CO5	3	2	3	1	2	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2
CO2	CD1, CD2,CD4, CD5
CO3	CD1, CD2, CD6
CO4	CD1, CD3,CD6
CO5	CD1,CD2,CD3

COURSE INFORMATION SHEET

Course code: MET507
Course title: Water and Wastewater Analysis Laboratory
Pre-requisite(s): B.Sc.
Co-requisite: -
Credits: 2 (L:0 T:0 P:4)
Class schedule per week: 4
Class: M.Sc.
Semester/Level: I/5
Branch: Environmental Science and Technology
Name of Teacher:

Course Objectives:
This course enables the students:

A.	To describe the concept of water quality concerning different standards
B.	To apply different procedures for the physico-chemical and bacteriological analysis of water and wastewater
C.	To assess the optimum dosing of chemicals for water treatment

Course Outcomes:
After the completion of this course, students will be able to:

1.	Explain the importance of water quality and various standards
2.	Choose different procedures for the physico-chemical and bacteriological analysis of water and wastewater samples.
3.	Understand and suggest water and wastewater treatment requirements.

Syllabus

1. Determination of pH, EC and turbidity of water
2. Determination of total solids, total dissolved solids and total suspended solids of wastewater
3. Determination of acidity and alkalinity of water and wastewater
4. Determination of total hardness and Calcium hardness of water
5. Determination of dissolved oxygen (DO) and BOD wastewater
6. Determination of COD of wastewater
7. Determination of chloride and residual chlorine of water
8. Determination of nitrate and sulphate in water and wastewater
9. Determination of phosphate in water and wastewater
10. Coliform count of water and wastewater samples by the MPN method

Textbooks:

1. Standard Methods of Testing of Water and Wastewater Use by APHA, AWWA, AND WPCF (USA)
2. Chemistry for Environmental Engineering, Clair N. Sawyer, Perry McCarty, Gene F. Parkin, McGraw-Hill Inc., New York, USA

Gaps in the syllabus (to meet Industry/Profession requirements) POs met through Gaps in the Syllabus, Topics beyond the syllabus/Advanced topics/Design

POs met through Topics beyond the syllabus/Advanced topics/Design

Course Delivery Methods	
Lectures by use of boards/LCD projectors/OHP projectors	CD1
Tutorials/Assignments	CD2
Seminars	CD3
Mini projects/Projects	CD4
Laboratory experiments/teaching aids	CD5
Industrial/guest lectures	CD6
Industrial visits/in-plant training	CD7
Self-learning, such as the use of NPTEL materials and the internet	CD8
Simulation	CD9

Gaps in the syllabus (to meet Industry/Profession requirements)
Design of real-time industrial projects.
POs met through Gaps in the Syllabus: PO4, PO5 & PO6.

POs met through Gaps in the Syllabus.

Topics beyond the syllabus/Advanced topics/Design
POs met through Topics beyond syllabus/Advanced topics/Design: PO4, PO5 & PO6.

Course Delivery Methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training
Self-learning, such as the use of NPTEL materials and the internet
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	**% Contribution during CO Assessment**
Quiz Marks	30
Assignment	10
Seminar	10
End Sem Examination Marks	50

Assessment Components	**CO1**	**CO2**	**CO3**
Quiz Marks	3	3	3
End Sem Examination Marks	3	3	3
Assignment	3	3	3

Indirect Assessment:
1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Outcomes into Program Outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	3	2	2
CO2	3	2	2	3	1	1
CO3	3	3	2	3	1	1

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery Methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO 1, 2, 3	CD1 & CD2
CD2	Tutorials/Assignments		CO 1, 2, 3	CD1 & CD2
CD3	Seminars			
CD4	Mini projects/Projects			
CD5	Laboratory experiments/teaching aids			
CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self-learning, such as the use of NPTEL materials and the internet			
CD9	Simulation			

SECOND SEMESTER

COURSE INFORMATION SHEET

Course code	**:**	**MET25508**
Course title	**:**	**Occupational Health and Industrial Safety**
Pre-requisite(s)	**:**	**B.Sc.**
Co-requisite	**:**	**-**
Credits	**:**	**3 (L:3 T:0 P:0)**
Class schedule per week	**:**	**3**
Class	**:**	**M.Sc.**
Semester / Level	**:**	**I/5**
Branch	**:**	**Environmental Science & Technology**
Name of Teacher	**:**	

Course Objectives

This course enables the students to:

1	To develop a fundamental understanding of industrial hazards and the associated risks present in various occupational settings
2	To introduce students to industrial safety management systems and the methods employed for ensuring worker health and safety
3	To familiarize students with the relevant acts, regulations, and legal frameworks governing occupational and industrial safety

Course Outcomes

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

CO1	Understand the development, structure, and necessity of safety management systems in industrial settings.
CO2	Identify potential workplace hazards and risks, and recommend appropriate mitigatory measures.
CO3	Gain knowledge of various hazard control methods, including engineering controls, administrative strategies, and personal protective equipment (PPE).
CO4	Understand and interpret relevant national and international safety standards.
CO5	Analyze and apply key Occupational Safety, Health, and Environment (OSHE) principles within the context of Indian industries, integrating appropriate legal and regulatory frameworks.

Occupational Health and Industrial Safety

Module 1: Industrial Hazards

Introduction to Hazards in industries and Classification, Principles of Hazard Identification and Risk Assessment (HIRA)**,** Risk Analysis Tools, Industrial Hygiene: Exposure Pathways, Control Strategies, Threshold Limit Values

Module 2: Occupational Health and Safety Management

Occupational Health and Safety Management Systems (OHSMS):ISO 45001, ILO Guidelines**;** Structure of Safety Management System**;** Roles and Responsibilities: Safety Officers, Safety

Committees**;** Occupational Health: Objectives, Common Occupational Diseases, Ergonomics**;** Safety Training and Behaviour-Based Safety (BBS)**;** Workplace Wellness and Health Surveillance

Module 3: Accident Causation, Prevention, and Control
Accident Theories: Domino Theory, Multiple Causation Theory, Human Error Model; Preventive Measures and Corrective Actions**;** Economic and Social Liabilities of Industrial Accidents**;** Emergency Preparedness and Response: On-site and Off-site Emergency Plans, Mock Drills, Fire Safety Systems**;** Disaster Risk Reduction and First Aid Protocols

Module 4: Hazard Control Techniques and Personal Protection
Hierarchy of Hazard Controls: Elimination, Substitution, Engineering, Administrative, and PPE**;** Machine Guarding: Principles and Devices**;** Personal Protective Equipment (PPE): Types (Respiratory and Non-respiratory), Standards (BIS, ISI, ANSI), Use and Maintenance**;** Fire Detection and Suppression Systems**;** Control of Noise, Vibration, and Temperature Hazards**;** Ventilation and Indoor Air Quality in Workplaces

Module 5: Environmental Legislation and Sustainable Management
Indian Environmental and Safety Laws: Factories Act (1948), Environment Protection Act (1986), Public Liability Insurance Act (1991), Contract Labour Act (1970), BOCW Act (1996), Hazardous Waste Management Rules**;** International Frameworks and Agreements: Basel Convention.

Books recommended:

TEXTBOOKS:

1. R.K.Jain and Sunil S.Rao , Industrial Safety, Health and Environment Management Systems, Khanna publishers , New Delhi (2006) (**T1**)
2. Herman Koren and Michel Bisesi, Handbook of Environmental Health and Safety: Jaico Publishing House, Delhi (1999). (**T2**)
3. Rao.S /Saluja H.L., Electrical Safety, Fire Safety Engineering and Safety Management, Publishers: Khanna Publishers, 1998 (**T3**)
4. L.M. Deshmukh, Industrial safety management, Tata Mcgraw Hill, New Delhi, 2006. (**T4**)

REFERENCE BOOKS:

1. **"Industrial Safety, Health, and Environment Management Systems"** – R. K. Jain & Sunil S. Rao
   Covers Indian laws like the OSHWC Code, 2020, The Environment Protection Act, and BIS safety standards.
2. **"Occupational Health and Safety Management: A Practical Guide"** – Charles D. Reese
   Reference for ISO 45001, OSHA standards, and global safety practices.

<u>Gaps in the syllabus (to meet Industry/Profession requirements)</u>:
Exposure to real situations in Industry.

POs met through Gaps in the Syllabus: **PO4, PO5 & PO6**
<u>Topics beyond syllabus/Advanced topics/Design:</u>

Field trips to industries to get exposed to real-life safety management systems

POs met through Topics beyond syllabus/Advanced topics/Design: **PO4, PO5 & PO6**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS AND EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 (3 X 10)
Assignment(s)	10
Seminar before a Committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	✓	✓	✓	✓	✓
Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	1	2	3	3	1	2
CO2	2	2	2	3	1	3
CO3	2	2	2	3	1	2
CO4	1	3	2	3	2	3
CO5	1	3	2	3	2	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD4, CD5, CD6
CO2	CD1, CD2, CD4, CD5, CD6
CO3	CD1, CD2, CD4, CD5, CD6
CO4	CD1, CD2, CD4, CD5, CD6
CO5	CD1, CD2, CD4, CD5, CD6

COURSE INFORMATION SHEET

Course code: MET25509
Course title: Soil Pollution and Solid Waste Management
Pre-requisite(s): B.Sc.
Co-requisite(s): NA
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 3
Class: M.Sc.
Semester / Level: 2nd SEMESTER/Level 5
Branch: Environmental Science and Technology
Name of Teacher:

Course Objectives
This course enables the students:

1.	To study the fundamentals of soil pollution
2.	To develop knowledge on remediation of contaminated land
3.	To understand the components of a solid waste management system.
4.	To study the collection, transfer and transport of municipal solid waste.
5.	Examine the treatment options and study operations of various material, resource, and energy recovery facilities.

Course Outcomes
After the completion of this course, students will be:

1.	Able to assess the levels of soil pollution
2.	Able to apply different methods for remediation of contaminated land
3.	Able to review the components and characteristics of a solid waste management system.
4.	Able to identify municipal solid waste management's various collection, transfer and transport mechanisms.
5.	Able to design and operate various processing, material and energy recovery facilities.

Syllabus

Module I **[8 Lectures]**
Soil Pollution
Sources and chemical nature of soil contaminants, distribution of soil contaminants: Soil–water partition process, soil-organism processes, soil pollution – elements, pesticides, Ecological and health effects of soil contaminants.

Module II **[8 Lectures]**
Contaminated Land Remediation
Contaminated land remediation - physico-chemical, biological and thermal methods, biodegradation of pollutants in land – factors affecting the bioremediation, phytoremediation, bio-stimulation, bio-augmentation.

Module III **[8 Lectures]**

Fundamentals of Solid Waste Management:

Municipal Solid Waste: Sources, types, waste generation rates, factors affecting generation, composition, MSW characteristics, effects of improper disposal, functional elements of solid waste management, the concept of ISWM system.

Module IV **[8 Lectures]**

Waste collection, transportation and processing:

Methods of collecting municipal solid wastes, collection vehicles, manpower, collection routes, vehicle routing, transfer station – location and operation. Waste processing, component separation and volume reduction. Zero waste management.

Module V **[8 Lectures]**

MSW energy and resource and ultimate disposal

Composting, biomethanation, incineration, pyrolysis, sanitary landfill, landfill leachate management and gas control; Landfill closure - environmental monitoring systems for landfill sites.

Textbooks:

1. Tchobanoglous G., Theisen H., Vigil S.: Integrated Solid Waste Management Engineering Principles and Management Issues. Mc-Graw Hill
2. Khan Iqbal H., Ahsan, N.: Textbook of Solid Waste Management. CBS Publisher and Distributors (P) Ltd.
3. Bhatia S.C.: Handbook of Industrial Pollution & Control Vol. 1 (CBS Publishers)
4. G M Masters and Wendell P Ela, Introduction to environmental engineering and science, Pearson
5. Gary W. Vanloon and Stephen J. Duffy.: Environmental Chemistry – a global perspective.

Reference books:

1. CPHEEO, Ministry of Urban Development: Manual on Municipal Solid Waste Management 2016
2. 2. CPHEEO, Ministry of Urban Development: Manual on Municipal Solid Waste Management 2000

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus.

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design.

Course Delivery methods	
Lectures by use of boards/LCD projectors/OHP projectors	✓
Tutorials/Assignments	✓

Seminars	✓
Mini projects/Projects	✓
Laboratory experiments/teaching aids	✓
Industrial/guest lectures	✓
Industrial visits/in-plant training	✓
Self- learning such as use of NPTEL materials and internets	✓
Simulation	✓

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Quiz Marks	30
Assignment	10
Seminar	10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Quiz Marks	3	3	3	3	3
End Sem Examination Marks	3	3	3	3	3
Assignment	3	3	3	3	3

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Outcomes into Program Outcomes

Course Outcome #	Program Outcomes					
	1	2	3	4	5	6
1	3	3	1	2	2	3
2	2	3	1	2	1	1
3	3	3	1	1	1	2
4	3	3	1	1	3	1
5	3	3	1	3	3	1

COURSE INFORMATION SHEET

Course Code: MET25510
Course Title: Air Pollution and Global Climate Change
Pre-requisite(s): B.Sc.
Credits: L: 3 T: 0 P: 0
Class schedule per week: 3
Class: M.Sc.
Semester / Level: II/5
Branch : M.Sc. Environmental Science and Technology
Name of Teacher:

Course Objectives: This course enables the students to:

A.	Understanding the basic concepts of ambient and indoor air pollution.
B.	Plan and execute air pollution sampling, monitoring and control.
C.	Apply the knowledge of air pollution modeling.
D.	Develop scientific reasoning of global climate change issues
E.	Execute climate change adaptation and mitigation plan

Course Outcomes
After the completion of this course, students will be able to:

1.	Design an air pollution sampling and monitoring plan.
2.	Air pollutants prediction modeling.
3.	Suggest suitable air pollution control devices and prepare action plan for control of air pollution
4.	Evaluate the regional and global impacts of climate change on ecosystems and human systems
5.	Examine policy responses and international agreements related to climate change mitigation and adaptation and propose effective strategies for climate resilience and sustainable development

Syllabus

Module I

[8 Lectures]

Air Pollution and air quality monitoring:
Sources and types of ambient and indoor air pollution; concept of airshed, effects of air pollution in regional and global scale. Ambient and indoor air sampling methods and devices, stack monitoring, CPCB guidelines for air quality monitoring, analysis of air pollutants and interpretation of air pollution data, source apportionment, air pollution standards and indices.

Module II: **[8 Lectures]**

Atmospheric meteorology and dispersion of air pollutants:
Temperature lapse rates and atmospheric stability, inversions, wind profiles, wind velocity and turbulence, plume behavior, estimation of plume rise, dispersion equations, box model, Gaussian plume model**.**

Module III

[8 Lectures]

Particulate matter and gaseous pollutants control technologies:
Control methods for air pollution, particulate matter and gaseous air pollution control equipment, vehicular pollution and control, national programs and action plans.

Module IV

[8 Lectures]

Fundamentals of climate change
Radiation balance, Greenhouse effects, greenhouse gases, radiative forcing and feedbacks, Natural variability: solar cycles, volcanic activity, ocean-atmosphere interactions (ENSO, AMO), anthropogenic causes, Climate change indicators: temperature trends, sea level rise, glacier retreat, ocean acidification, Types of climate models and their components, IPCC scenarios (RCPs, SSPs) and future projections, Climate sensitivity and uncertainty in predictions.

Module V

[8 Lectures]

Impact, adaptation and mitigation of climate change
Effects on ecosystems, biodiversity, agriculture, water resources, and health, vulnerable regions and communities (e.g., small islands, coastal areas, arid zones), Climate justice and equity issues, Mitigation strategies: renewable energy, carbon sequestration, emission trading, afforestation, Adaptation planning and community-based adaptation, UNFCCC, Kyoto Protocol, Paris Agreement, National policies: NAPCC, SAPCC, climate action plans, concept of net zero.

TEXTBOOKS:

1. Environmental Engineering- Peavy & Rowe. Prentice Hall Pub.
2. Air Pollution Control – Rao and Rao
3. Environmental Pollution and Control – C.S. Rao
4. Houghton, J. (2015). *Global Warming: The Complete Briefing*. Cambridge University Press

5. Maslin, M. (2021). *Climate Change: A Very Short Introduction*. Oxford University Press

REFERENCE BOOKS:

1. Noel de Nevers, Air Pollution Control Engineering, Mc Graw Hill, New York.
2. Arthur C. Stern, Air Pollution (Vol. I – Vol. VIII), Academic Press
3. Introduction to Environmental Engineering and Science, Gilbert M Masters
4. CPCB manual for Guidelines for ambient air quality monitoring. Published By: Dr. B. Sengupta, Member Secretary, Central Pollution Control Board

6. IPCC Assessment Reports (AR6) – Working Groups I, II, and III
7. Parikh, J., and Parikh, K. (2012). *India's Climate Change Policy*. Springer
8. Government of India. *NAPCC and SAPCC Reports* (MoEFCC website)

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

DIRECT ASSESSMENT

Assessment Tool	% Contribution during CO Assessment
Quizzes (3)	3x10 = 30
Seminar	10
Teacher's Assessment	10
Semester End Examination	50

INDIRECT ASSESSMENT –

1. Students' Feedback on Course Outcome

MAPPING OF COURSE OUTCOMES ONTO PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	3	2	2	2
CO2	2	3	3	3	2	3
CO3	2	3	3	2	2	2
CO4	2	3	3	3	3	3
CO5	2	3	3	2	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Gaps in the syllabus (to meet Industry/Profession requirements):
Design of real-time industrial projects.

POs met through Gaps in the Syllabus: None

Topics beyond syllabus/Advanced topics/Design: Air pollution modelling software POs met through Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design: None

Course Delivery Methods

CD	Course Delivery methods
CD1	Lecture by use of boards/LCD projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Industrial visits/in-plant training
CD5	Self- learning such as use of NPTEL materials and internets
CD6	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Mapping Between COs and Course Delivery (CD) methods	
Course Outcome	**Course Delivery Method**
CO1	CD1, CD2, CD3, CD5
CO2	CD1, CD2, CD3, CD5
CO3	CD1, CD2, CD3, CD5
CO4	CD1, CD2, CD3, CD5
CO5	CD1, CD2, CD3, CD5

COURSE INFORMATON SHEET

Course code: MET25511
Course Title: Application of Remote Sensing in Environment
Pre-requisite(s): B.Sc.
Co-requisite : -
Credits : 3 (L:3 T:0 P:0)
Class schedule per week: 3
Class: M.Sc.
Semester / Level:
Branch : Environmental Science & Technology
Name of Teacher:

Course objectives
This course enables the students to:

1	To develop basic understanding of remote sensing and GIS
2	To interpret and develop understandings on satellite image interpretation and indices
3	To be able to apply Remote sensing and GIS in environmental components

Course Outcomes:
At the end of the course, a student should be able to:

CO1	Understand working principles of remote sensing, and spectral responses
CO2	To understand the Procurement process of Data, their interpretation and history of India and global satellite data
CO3	Integrate the applications of Air borne platforms
CO4	Apply processing tools to classify land use and land cover
CO5	Understand GIS concepts and their environmental application

Syllabus

Module I **[8 Lectures]**

Principles of Remote Sensing:

Definition and Historical overview, Image Procurement, Electromagnetic spectrum, Atmospheric Windows, Physics of Remote Sensing, Spectral Signatures, Spectral Response pattern of soil, Vegetation & water.

Module II **[8 Lectures]**

Satellite, Sensors and Image Interpretation:

Imaging & non-imaging sensors, Active & passive sensors, High- and Low-resolution sensors, Sensor Resolutions, Indian and Global Satellites, Fundamentals of Image Interpretation Techniques. Applications of different sensors.

Module III **[8 Lectures]**

Platforms and Aerial Vehicles :

Aerial Photography, platforms, UAVs and their applications in environmental management and Biodiversity conservation

Module IV **[8 Lectures]**

Image Processing :

Contrast Enhancement, Filtering, Band Ratio and Indices. Supervised Classification and Unsupervised Clustering. Applications of processing tools in environmental management.

Module V **[8 Lectures]**

Principles of GIS:

GIS Concepts, Vector Data, Raster Data, Point, line, Polygon, GIS Applications in Environmental Management.

Books Recommended:

TEXTBOOK

1. Jensen, J.R., (2006) "Remote Sensing of the Environment – An Earth Resources Perspective", Pearson Education, Inc. (Singapore) Pvt. Ltd., Indian edition, Delhi.
2. 2. Jensen, J.R., (1996) Introductory Digital Image Processing A remote sensing perspective. Prentice Hall Series in GIS, USA
3. 3. Lillesand, Thomas M. and Kiefer, Ralph, W., (2007) "Remote Sensing and Image Interpretation", 4th Edition, John Wiley and Sons, New York

REFERENCE BOOK

1. Sabins, F.F. Jr., (2007). 'Remote Sensing – Principles and Interpretation", W.H. Freeman & Co.
2. Reeves, Robert G. (1991), "Manual of Remote Sensing, Vol. I, American Society of Photogrammetry and Remote Sensing, Falls Church, Virginia, USA

Gaps in the syllabus (to meet Industry/Profession requirements)

Application of real life industrial problems

POs met through Gaps in the Syllabus: PO5 and PO6

Topics beyond syllabus/Advanced topics/Design:

Application for real life problems arising in industries through lab-based experiments

POs met through Topics beyond syllabus/Advanced topics/Design: **PO5 and PO6**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS AND EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 (3 X 10)
Assignment(s)	10
Seminar before a Committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	2	1	3
CO2	3	3	3	3	1	2
CO3	3	1	3	3	1	2
CO4	3	2	3	3	3	3
CO5	3	2	3	2	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2
CO2	CD1, CD2, CD4, CD5
CO3	CD1, CD2, CD6, CD7
CO4	CD1, CD3, CD6, CD7
CO5	CD1, CD2, CD3,CD7

COURSE INFORMATION SHEET

Course code: MET25-512
Course title: Sustainability and Environmental Social Governance
Pre-requisite(s): B.Sc.
Co-requisite: -
Credits: 3 (L:3 T:0 P:0)
Class schedule per week: 3
Class: M.Sc.
Semester / Level:
Branch : Environmental Science & Technology
Name of Teacher:

Course Objectives:
This course aims to provide students with:

1	A comprehensive understanding of the concept of sustainable development and its global significance.
2	To introduce students to the concept and significance of ESG in modern business.
3	To analyze each pillar of ESG—Environmental, Social, and Governance—in detail.
4	To examine ESG investing and reporting frameworks in global and Indian contexts.
5	To critically evaluate real-world ESG practices through case studies.

Course Outcomes:

CO1	Understand ESG concepts and their strategic importance in business sustainability.
CO2	Evaluate environmental, social, and governance risks and opportunities for organizations.
CO3	Interpret ESG reports and investment metrics.
CO4	Apply ESG principles in analyzing corporate behavior and policy-making.

Syllabus

Module I **[8 Lectures]**
Foundations of ESG and Sustainability

Historical evolution, Brundtland Report, Sustainable Development Goals (SDGs), principles of sustainable development, challenges, and opportunities. Key definitions: Sustainability, CSR, triple bottom line, Intergenerational Equity, Carrying Capacity, and Ecological Footprint, Planetary Boundaries and Doughnut Economics, Global and National Sustainability Challenges. Importance of ESG in today's business environment, Regulatory frameworks and global standards (UN SDGs, GRI, SASB, TCFD, etc.), Key ESG Rating Agencies and Standards (e.g., GRI, SASB, TCFD, CDP)

Module II **[8 Lectures]**

Dimensions and Applications of Sustainability

Environmental Sustainability: Biodiversity, Ecosystems, Pollution, Climate Change, Resource Use, Social Sustainability: Equity, Education, Public Health, Gender, Community Development, Economic Sustainability: Green Economy, Circular Economy, Responsible Consumption and Production, Tools: Sustainability Indicators, Life Cycle Assessment (LCA), Material Flow Analysis (MFA), Sustainability in Urban Planning, Agriculture, Energy, and Industry.

Module III **[8 Lectures]**

Sustainability Strategies, Governance, and Innovations, Environmental Governance and International Protocols (UNFCCC, CBD, Rio Conventions), Corporate Sustainability: CSR, ESG, Sustainability Reporting, National Sustainability Policies (India: NAPCC, SDG India Index, State Actions), Technological Innovations in Sustainability: Clean Tech, Smart Cities, Renewable Energy, Public Participation and Stakeholder Engagement, Future Trends: AI for Sustainability, Net Zero Goals, Green Finance.

Module IV **[8 Lectures]**

Environmental and Social Dimensions of ESG

The 'E' of ESG: Climate Change, Energy Use, Waste, Emissions, Biodiversity

The 'S' of ESG: Human Rights, Labor Practices, DEI (Diversity, Equity, Inclusion), Community Engagement, Stakeholder Mapping and Materiality Assessment, Environmental and Social Risk Management, The 'G' of ESG: Corporate Governance, Board Composition, Ethics, Compliance, Principles of Transparency, Accountability, and Anti-Corruption, National Guidelines on Responsible Business Conduct (NGRBC), Role of SEBI and Indian Corporate Governance Codes

Module V **[8 Lectures]**

ESG Reporting, Investing, and Future Roadmap

ESG Reporting Standards and Best Practices (GRI, BRSR, CDP, SASB), ESG Rating and Benchmarking (MSCI, DJSI, Sustainalytics), ESG Investing, Green Finance, and Impact Investing., Stakeholder Communication and Avoiding Greenwashing, Corporate Strategy and ESG Integration, Future Trends in ESG: Digital ESG, AI and Sustainability, Circular Economy.

Books Recommended:

TEXTBOOKS:

1. Sustainable Development: Exploring the Contradictions - John Robinson
2. Our Common Future - World Commission on Environment and Development
3. Sustainable Development Goals: Harnessing Business to Achieve the SDGs through Finance, Technology and Law Reform - Julia Walker et al.
4. The ESG Imperative: How Sustainability and Climate Risk are Changing Business By Robert G. Eccles, Mary Johnstone-Louis, Colin Mayer

REFERENCE BOOKS:

1. Sustainability: A Comprehensive Foundation - Tom Theis and Jonathan Tomkin

2. Green Economy and Good Governance for Sustainable Development - José Antonio Puppim de Oliveira
3. Environment and Development: Basic Principles, Human Activities, and Environmental Implications - Stavros G. Poulopoulos and Vassilis J. Inglezakis
4. Sustainable Investing: Revolutions in Theory and Practice, By Herman Bril, Georg Kell, Andreas Rasche (Eds.)

Gaps in the Syllabus (to meet Industry/Profession requirements):
Practical exposure to real-world sustainable development projects.

POs met through Gaps in the Syllabus: NA

Topics beyond syllabus/Advanced topics/Design:
Digital tools and software for sustainable development impact assessment.

POs met through Topics beyond syllabus/Advanced topics/Design: -

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS AND EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 (3 X 10)
Assignment(s)	10
Seminar before a Committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	✓	✓	✓	✓	✓
Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	2	2	1	3
CO2	2	3	2	1	1	3
CO3	2	3	3	2	2	3
CO4	2	2	2	3	1	3
CO5	3	3	2	3	1	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2
CO2	CD1, CD2
CO3	CD1, CD2
CO4	CD1, CD2
CO5	CD1, CD2

COURSE INFORMATION SHEET

Course code: MET25513
Course title: Air and Soil Laboratory
Pre-requisite(s): B.Sc.
Co- requisite(s): -
Credits: 2 L: 0 T: 0 P: 4
Class schedule per week: 4
Class: M. Sc.
Semester / Level: 2ND SEMESTER/ LEVEL 5
Branch: M.Sc. Environmental Science and Management

Course Objectives

This course enables the students:

A.	To monitor and analyse the air pollution level of the ambient air.
B.	To determine some important soil properties and assess its effect on environmental quality.

Course Outcomes

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

1.	Design and implement ambient air quality monitoring plan.
2.	Interpret the air quality data and evaluate the air pollution status.
3.	Examine some of the soil physico-chemical properties.
4.	Interpret soil environmental quality and fertility status.

Syllabus

1. Monitoring and analysis of PM_{10} and $PM_{2.5}$ in the ambient air.
2. Sampling and analysis of NOx by chemiluminescence method.
3. Sampling and analysis of CO_2 and CO by NDIR method.
4. Sampling and analysis of sulphur dioxide in ambient air (Improved West and Gaeke method)
5. Sampling and analysis of Lead, Nickel and Arsenic in ambient air.
6. Determination of particle size distribution in fine aggregates.
7. To determine the soil particle size distribution by hydrometer analysis.
8. To determine the moisture content of soil by gravimetric method.
9. To estimate NPK status of soil.
10. To determine the pH, EC of the soil solution.

Textbooks:

1. Soil Testing for Engineers- Lambe T.W., Wiley Eastern Ltd., New Delhi. 5. Manual of
2. Soil Laboratory Testing- Head K.H., (1986)- Vol. I, II, III, Princeton Press, London

Reference books:

1. Guidelines for the Measurement of Ambient Air Pollutants, CPCB, 2013.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	✓
Tutorials/Assignments	
Seminars	
Mini projects/Projects	
Laboratory experiments/teaching aids	✓
Industrial/guest lectures	
Industrial visits/in-plant training	✓
Self- learning such as use of NPTEL materials and internets	✓
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	**% Contribution during CO Assessment**
Progressive Evaluation Marks	60
End Examination Marks	40

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**
Progressive Evaluation Marks	✓	✓	✓	✓
End Examination Marks	✓	✓	✓	✓

Indirect Assessment –

1. Student feedback on teaching quality and teaching methods adopted
2. Student feedback on course syllabus and course outcome

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

Course Outcome	Program Outcomes					
	1	**2**	**3**	**4**	**5**	**6**
1	3	3	2	3	3	2
2	3	3	2	3	3	2
3	3	3	2	3	3	2
4	3	3	2	3	3	2

CD	**Course Delivery methods**	**Course Outcome**
CD1	Lecture by use of boards/LCD projectors/OHP projectors	All COs
CD2	Tutorials/Assignments	
CD3	Seminars	
CD4	Mini projects/Projects	
CD5	Laboratory experiments/teaching aids	All COs
CD6	Industrial/guest lectures	
CD7	Industrial visits/in-plant training	
CD8	Self- learning such as use of NPTEL materials and internets	
CD9	Simulation	

COURSE INFORMATION SHEET

Course code: MET25514
Course title: Remote Sensing Lab
Pre-requisite(s): B.Sc.
Co-requisite:-
Credits: 2 (L:0 T:0 P:4)
Class schedule per week: 4
Class: M.Sc.
Semester / Level:
Branch: Environmental Science & Technology
Name of Teacher :

Course objectives
This course enables the students to:

1	To interpret and develop understandings on satellite image interpretation and classification
2	To be able to download data sets and use Google earth in basic studies.
3	To be able to prepare maps with attributes and information tables

Course Outcomes:
At the end of the course, a student should be able to:

CO1	Identify features using FCC and ground surveys
CO2	To extract features based in suitable indices
CO3	To classify features and estimate areas based in suitable classifiers
CO4	Apply processing tools in GIS, generate maps and add
CO5	Explore Google earth for basic studies

Syllabus

List of Experiments

Experiment 1: To perform feature identification using keys to Image Interpretation.

Experiment 2: Feature Validation using Image interpretation keys, Ground truthing surveys and Geotagging of locations.

Experiment 3: To perform Vegetation assessment of an area using multiple indices.

Experiment 4: To perform Water resource assessment of an area using multiple indices.

Experiment 5: To perform Built-up Area assessment of an area using multiple indices.

Experiment 6: To perform Elevation profiling Study using Google Earth Pro.

Experiment 7: To perform Supervised Land Use and land Cover Classification

Experiment 8: To perform Supervised Land Use and land Cover Classification

Experiment 9: To download satellite data sets from USGS sites.

Experiment 10: To prepare a point line polygon map with attributes using ARC GIS

Books recommended:

Jensen, J.R., (2006) "Remote Sensing of the Environment – An Earth Resources Perspective", Pearson Education, Inc. (Singapore) Pvt. Ltd., Indian edition, Delhi

Sabins, F.F. Jr., (2007). 'Remote Sensing – Principles and Interpretation", W.H. Freeman & Co.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

Drone survey, Exposure to LiDAR Survey.

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS AND EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Progressive evaluation	60
Semester End Examination	40

Continuous Internal Assessment	% Distribution
Day-to-day performance and Lab files	30
Quiz	15
Viva	15

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	✓	✓	✓	✓	✓
Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery methods

CD1	Instruction by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments
CD4	Guest lectures
CD5	Visit to different ecosystems
CD6	Self- learning such as use of NPTEL materials and internets

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	1	1	1
CO2	3	2	3	1	1	1
CO3	3	2	3	1	1	1
CO4	3	2	3	1	1	2
CO5	3	2	3	1	2	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2
CO2	CD1, CD2, CD4, CD5
CO3	CD1, CD2, CD6
CO4	CD1, CD3, CD6
CO5	CD1, CD2, CD3

THIRD SEMESTER

COURSE INFORMATON SHEET

Course code: MET25516
Course Title: Earth Science and Energy Resources
Pre-requisite(s): B.Sc.
Co-requisite : -
Credits : 3 (L:3 T:0 P:0)
Class schedule per week: 3
Class: M.Sc.
Semester / Level:
Branch : Environmental Science & Technology
Name of Teacher:

Course objectives
This course enables the students to:

1	**To understand** the origin and internal structure of the Earth and the fundamental processes shaping the planet's surface and atmosphere.
2	**To develop knowledge** of the principles of hydrology and hydrogeology including groundwater movement, quality, and contamination.
3	**To explore** geochemical processes controlling the distribution and cycling of elements in the Earth's system including soils and sediments.
4	**To identify and evaluate** various geological and climatic hazards and understand prediction and mitigation strategies.
5	**To recognize** the environmental implications of natural resource exploitation and the need for conservation and sustainable management.

Course Outcomes:
At the end of the course, a student should be able to:

CO1	Explain the formation and structure of Earth, and analyze the processes governing energy balance, atmospheric circulation, and climatic patterns.
CO2	Describe geochemical cycles, soil formation processes, and classify soils and minerals based on their chemical and physical characteristics.
CO3	Apply hydrogeological principles to understand groundwater behavior, pollution risks, and assess aquifer properties using Darcy's law and related parameters.
CO4	Identify and evaluate natural hazards such as earthquakes, floods, and landslides, and propose mitigation and risk reduction measures.
CO5	Assess the impact of natural resource exploitation and advocate for responsible, sustainable environmental practices.

Syllabus

Module I

Earth Systems and Geodynamic Processes

Origin and evolution of Earth: primary geochemical differentiation, plate tectonics and formation of the core, mantle, crust, atmosphere, and hydrosphere. Fundamentals of minerals and rocks; formation processes of igneous and metamorphic rocks, Earth's energy budget and thermal regime; concept of steady state and equilibrium, Atmospheric forces: Coriolis force, pressure gradient, frictional force, geostrophic and gradient winds, Earth's climate systems: Indian monsoon, western disturbances, droughts, El Niño and La Niña Climates of India and seasonal variations, Concept of residence time and rates of geochemical and natural cycles, Geophysical fields and their significance, Paleoclimate studies and reconstruction of past environments

Module II

Weathering, minerals and Soil Science and Oceanography

Minerals and their classifications. Marine mineral resources: oceans and new frontiers. Natural resource exploration and exploitation and related environmental concerns. National Mineral Policy and best management practices in mining. Processes of weathering: physical, chemical (including weathering reactions), and biological, Erosion, sediment transport, and depositional mechanisms, Soil formation: soil-forming minerals, pedogenic processes, and climatic control, Soil classification, types, and physical–chemical characteristics. Oceanography: Reliefs of the ocean, temperature, salinity and density of the ocean water, ocean tides, currents, coral and marine resources.

Module III

Hazards, and Natural Resource Management

Distribution of water on Earth: surface and subsurface, Principles of hydrology and hydrogeology, major river basins and groundwater provinces of India, Darcy's Law and its applicability in groundwater flow, Groundwater dynamics: fluctuations, hydraulic conductivity, tracers, Groundwater contamination and quality parameters, Effects of over-extraction: land subsidence and saltwater intrusion (Ghyben-Herzberg relation), Geological and climatic hazards: floods, earthquakes, landslides, volcanism, avalanches, tsunamis, cloudbursts, Hazard prediction techniques and mitigation strategies. Natural Hazards: Catastrophic geological hazards - floods, landslides, earthquakes, volcanism, avalanche, tsunami and cloud bursts. Prediction of hazards and mitigation of their impacts.

Module IV

Conventional Energy Resources and Environmental Impact

Concept and classification of energy sources: Renewable vs. Non-renewable, Conventional vs. Non-conventional; Fossil fuels: classification, composition, physico-chemical characteristics and energy content of coal, petroleum and natural gas. Shale oil, Coal bed Methane, Gas hydrates. Gross-calorific value and net-calorific value, exploration, extraction, and usage;

Fossil-fuel-based power plants and environmental effects; Nuclear energy: Nuclear fission and fusion, nuclear fuel cycle and waste management.

Module V

Renewable Energy Resources and Emerging Technologies

Solar energy: Passive and active solar systems, Solar collectors, solar ponds, photovoltaic cells; Wind energy: generation, technology, and limitations; Ocean energy: Ocean Thermal Energy Conversion (OTEC), Tidal and wave energy; Geothermal energy: sources, extraction, and utilization; Biomass and bioenergy: Types of biomass and conversion methods (e.g., gasification); Biogas, algae, petro-crops, and aquatic weeds; Environmental benefits of renewable energy; Future prospects of renewable and bioenergy systems; National and global renewable energy initiatives and policies.

Books recommended:

TEXTBOOKS:

- **Press, F., & Siever, R. (2001)** – *Understanding Earth*, W.H. Freeman
- **Strahler, A.N., & Strahler, A.H. (2005)** – *Physical Geography: Science and Systems of the Human Environment*, Wiley
- **Todd, D.K., & Mays, L.W. (2005)** – *Groundwater Hydrology*, Wiley

REFERENCE BOOKS:

- **Karanth, K.R. (1987)** – *Groundwater Assessment, Development and Management*, Tata McGraw-Hill
- **Selley, R.C. (2000)** – *Applied Sedimentology*, Academic Press
- **Lutgens, F.K., Tarbuck, E.J., & Tasa, D. (2019)** – *Essentials of Geology*, Pearson
- **Thorpe, A. (2012)** – *The Elements: A Very Short Introduction*, Oxford University Press
- **Mason, B., & Moore, C.B. (1982)** – *Introduction to Geochemistry*, Wiley
- **Ritter, D.F., Kochel, R.C., & Miller, J.R. (2011)** – *Process Geomorphology*, Waveland Press
- **Bryant, E. (2005)** – *Natural Hazards*, Cambridge University Press

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:
Drone survey, Exposure to LiDAR Survey.

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS AND EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Progressive evaluation	60
Semester End Examination	40

Continuous Internal Assessment	% Distribution
Day-to-day performance and Lab files	30
Quiz	15
Viva	15

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	✓	✓	✓	✓	✓
Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery methods

CD1	Instruction by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments
CD4	Guest lectures
CD5	Visit to different ecosystems
CD6	Self- learning such as use of NPTEL materials and internets

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	1	1	1
CO2	3	2	3	1	1	1
CO3	3	2	3	1	1	1
CO4	3	2	3	1	1	2
CO5	3	2	3	1	2	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2
CO2	CD1, CD2, CD4, CD5
CO3	CD1, CD2, CD6

CO4	CD1, CD3, CD6
CO5	CD1, CD2, CD3

Programme Electives

COURSE INFORMATION SHEET

Course code	**:**	**MET25523**
Course title	**:**	**Environmental Toxicology**
Pre-requisite(s)	**:**	**B.Sc.**
Co-requisite	**:**	**-**
Credits	**:**	**3 (L:3 T:0 P:0)**
Class schedule per week	**:**	**3**
Class	**:**	**M.Sc.**
Semester / Level	**:**	**I/5**
Branch	**:**	**Environmental Science & Technology**
Name of Teacher	**:**	

Course Objectives

This course enables the students to:

1	Understand the fundamental principles of toxicology, including dose-response relationships and toxicity mechanisms
2	Analyze the sources, transport, transformation, and environmental fate of various toxicants
3	Examine the ecotoxicological impacts of pollutants at multiple biological levels, from organisms to ecosystems

Course Outcomes

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

CO1.	Explain key toxicological principles
CO2.	Assess the sources, transport, transformation, and fate of environmental toxicants
CO3	Analyze ecotoxicological effects at different biological levels
CO4	Evaluate occupational toxicology risks and exposure limits
CO5	Apply ecotoxicity assessment methods and safety regulations

Syllabus

Module I: Introduction to Environmental Toxicology

Definition, scope, and importance of environmental toxicology; Routes of exposure: ingestion, inhalation, dermal; Dose-response relationship: key terms (LD_{50}, LC_{50}, NOEL, threshold dose); Types of toxicity: Acute vs. Chronic, Systemic vs. Local; Factors influencing toxicity: age, sex, genetics, other chemical interactions; Concept of bioaccumulation, biomagnification, bioconcentration

Module II: Environmental Pollutants and Their Fate

Major classes of pollutants: Inorganic, organic, organometallic, radioactive, gaseous; How pollutants enter and move through the environment: Soil, air, water pathways; Fate and distribution of metals, radioactive materials, and organic pollutants in ecosystems; Behaviour of pollutants inside living organisms: uptake, storage, transformation

Module III: Toxicity Evaluation and Environmental Risk
Concept and need for toxicity evaluation in environmental science; Pollutant interactions: additive, synergistic, antagonistic effects; Steps in environmental risk assessment: Hazard identification, exposure assessment, dose-response, risk characterization; Safety limits and exposure standards (e.g., TLV, PEL); Use of Material Safety Data Sheets (MSDS)

Module IV: Biological and Ecological Effects of Pollutants
Effects at molecular, cellular, organ, and organism level, Common toxic effects: Liver damage, reproductive toxicity, respiratory issues, carcinogenicity; Detoxification mechanisms and protective enzymes; Biomarkers of exposure and effect; Changes in plant/animal communities and ecosystem functions due to pollution

Module V: Environmental Toxicology
Combined effects of pollutants: additive, synergistic, antagonistic, potentiation; Emerging contaminants: Microplastics, endocrine disruptors, nanoparticles; Molecular mechanisms of toxicity: DNA damage, enzyme inhibition; Tools and techniques: ELISA, Comet assay, Immunofluorescence (basic overview); Ethical considerations in toxicity testing: animal welfare, alternatives (CRED)

Books recommended:

TEXTBOOKS:

1. Environmental Toxicology set of 3 volumes- Peter Gomes
2. Aquatic Environment and Toxicology-Pawan Kumar Bhart
3. Toxicology: Principles and Methods-Second Revised Edition - M A Subramanian
4. Toxicology: A Manual for Students and Practitioners. - Edwin Welles Dwigh
5. Toxicology - Vijayan Kannampilly

REFERENCE BOOKS:

1. Modern Toxicology Vol I, II and III edited by P.K. Gupta and D.K. Salunkhe, Metropolitan Book Co. Pvt. Ltd.
2. Environmental Toxicology: Biological and Health Effects of Pollutants, Third Edition by Ming-Ho Yu (Author), HumioTsunoda (Author), Masashi Tsunoda (Author) CRC Press; 3 edition (14 December 2011) ISBN-13: 978-1439840382

Gaps in the syllabus (to meet Industry/Profession requirements):
POs met through Gaps in the Syllabus: **PO5 & PO6**

Topics beyond syllabus/Advanced topics/Design:
POs met through Topics beyond syllabus/Advanced topics/Design: **PO5 & PO6**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS AND EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 (3 X 10)
Assignment(s)	10
Seminar before a Committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	✓	✓	✓	✓	✓
Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	3	2	2
CO2	3	3	2	3	1	1
CO3	3	3	2	1	1	2
CO4	2	2	2	2	2	3
CO5	2	2	2	3	2	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD4, CD6
CO5	CD1, CD2, CD4, CD6

COURSE INFORMATION SHEET

Course code: MET25524
Course title: Environmental Statistics and Optimization
Pre-requisite(s): B.Sc.
Co-requisite: -
Credits:3 (L:3 T:0 P:0)
Class schedule per week : 3
Class: M.Sc.
Semester / Level:
Branch : Environmental Science & Technology
Name of Teacher:

Course Objectives

This course enables the students to:

1	Develop a general understanding of environmental statistics and optimization
2	Identify the areas of application of statistics in Environmental Science and Engineering. Also understand the principles of optimizing the natural resources
3	Apply the knowledge of statistical ideas and tools of optimization to solve problems in industry, management and other engineering fields.

Course Outcomes

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

CO1.	Able to demonstrate the applications of statistical and optimization techniques in Environmental Science and Engineering.
CO2.	Able to understand the necessity of frequency distribution in environmental samples.
CO3.	Able to plan and design surveys and experiments.
CO4.	Able to statistically analyse the relation and variability in environmental data and significance of optimization.
CO5.	Able to identify the components of statistical data structure needed for various environmental data collection and identify the tools for optimization.

Syllabus

Module I **[8 Lectures]**

Introduction to Environmental Statistics:

Objective and scope of Environmental Statistics, sources of environmental statistics, Environmental information, data, statistics and indicators, Spatial, temporal, geospatial information and environmental statistics. Collection and representation of data- Primary and Secondary data, collection and scrutiny of data, frequency and non-frequency data, diagrammatic representation of data.

Module II **[8 Lectures]**

Frequency Distributions and and sampling theory:

Attribute and variable, Discrete and continuous variable, frequency distribution of an attribute and variable. Measures of dispersion, measures of skewness and kurtosis. Hypothesis testing.

Module III **[8 Lectures]**

Correlation and regression and Analysis of Variance:
Correlation analysis, covariance, correlation coefficient, distribution of correlation coefficient and its statistical significance. Regression analysis, Analysis of variance – One-way and two-way Classifications.

Module IV **[8 Lectures]**

Introduction to optimization and its tools:
Definition of global and local optima, optimal problem formulation, Linear and nonlinear programming methods and their application in environmental systems
.

Module V **[8 Lectures]**

Introduction to modern statistical and optimization tools:
Statistical tools like SPSS, R software, Optimization tools like Neural network based optimization, Genetic algorithms, Application of GIS in optimization

Books recommended:

TEXTBOOKS:

1. Johnson, R. A. and Gupta, C. B., "Miller & Freund's Probability and Statistics for Engineers", Pearson Education, Asia.
2. Devore, J.L., "Probability and statistics for Engineering and the Sciences", Thomson and Duxbury, Singapore.
3. Johnson, R.A., and Wichern, D.W., "Applied Multivariate Statistical Analysis", Pearson Education, Asia.
4. Gupta, S.C., and Kapoor, V.K., "Fundamentals of Mathematical Statistics", Sultan Chand and Sons.
5. Gupta A. M., Goon M. K., Dasgupta B. Fundamentals of Statistics-I. World Press.
6. J.K.Sharma-Operation research , 3/e, Mcmillan, India Ltd, 2007

REFERENCE BOOKS:

1.Framework for the Development of Environment Statistics. United Nations Publications.

Gaps in the syllabus (to meet Industry/Profession requirements):
Design of real-time industrial projects.

POs met through Gaps in the Syllabus: **PO4, PO5 & PO6**
Topics beyond syllabus/Advanced topics/Design:

Computer based modeling, introduction of statistical software

POs met through Topics beyond syllabus/Advanced topics/Design: **PO4, PO5 & PO6**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS AND EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 (3 X 10)
Assignment(s)	10
Seminar before a Committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	✓	✓	✓	✓	✓
Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment

3. Student Feedback on Faculty
4. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	3	1	2	3
CO2	1	2	1	3	2	2
CO3	1	2	1	3	2	2
CO4	1	2	3	3	3	3
CO5	3	1	2	3	2	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: MET25525
Course title: INSTRUMENTAL METHODS FOR ANALYSIS OF ENVIRONMENTAL SAMPLES
Pre-requisite(s):
Co- requisite(s):
Credits: 3 L:3 T:0 P:0
Class schedule per week: 3
Class: M.Sc.
Semester / Level: 5
Branch: Environmental Science and Technology
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Understand the developments in the field of instrumentation for quantitative and qualitative analysis of environmental samples
2	Know the applications of spectroscopy, chromatography and electroanalytical methods
3	Select and finalize the instruments for different analysis of environmental samples
4	Carry out *in situ* and continuous environmental monitoring and assessment studies

Course Outcomes:
At the end of the course, a student should be able to:

CO1	Capable to select appropriate instrumental method for chemical analysis of air, water and soil
CO2	Apply spectroscopic, electro-chemical and chromatographic techniques for environmental samples analysis
CO3	Design studies related to in situ and continuous monitoring of atmospheric and aquatic systems

Syllabus

Module I **[8 Lectures]**
Environmental samples analysis:
Conventional methods and their limitations, Modern instrumental methods, selection of method, precision and accuracy, error in measuring signals, quality assurance and quality control, sample preservation, sample preparation and analyte isolation.

Module II **[8 Lectures]**
Spectroscopy:
Principles, techniques and applications of spectroscopy, fluorimetry, nephelometry and turbidimetry, Atomic Absorption Spectrometry (Flame, graphite furnace, cold vapour and hydride generation), Inducted Coupled Plasma Optical Emission Spectroscopy (ICP OES).

Module III **[8 Lectures]**

Chromatography:

Principles, techniques and applications of chromatography, Gas chromatography, GC-Mass spectroscopy, High performance liquid chromatography, LC - Mass spectroscopy, and Ion chromatography.

Module IV **[8 Lectures]**

Electro-analytical methods:

Conductometry, potentiometry, coulometry, AOX analyzer amperometry, polarography, Neutron Activation Analysis, X-ray Fluorescence and X-ray Diffraction.

Module V:

***In situ* and continuous monitoring systems:**

Principles, techniques and applications of CO analyser, NOx analyser, SO_2 analyser, particulate matter sampling and analysis, aethalometer, auto analyzer for water quality using flow injection analysis, in situ water quality parameter loggers.

Books recommended:

TEXTBOOK

1. Chemistry for Environmental Engineering, Clair N. Sawyer, Perry Mccarty, Gene F. Parkin, McGraw Hill Inc. New York (**T1)**
2. Willard H. Merritt, L. Dean, D.A. and Settle, F.A. Instrumental analysis methods Edn. Words Worth, New York (**T2)**
3. Paul R. Loconto Trace Environmental Quantitative Analysis: Principles, Techniques, and Applications, Marcel Dekker (**T3)**

REFERENCE BOOK

1. Instrumental Methods of Chemical Analysis, Ewing, McGraw-Hill, New York. (**R1**)

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS AND EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	**% Contribution during CO Assessment**
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 (3 X 10)
Assignment(s)	10
Seminar before a Committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	√	√	√	√	√
Semester End Examination	√	√	√	√	√

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	0	2	1
CO2	3	3	3	0	2	1
CO3	3	3	3	0	2	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1
CO2	CD1, CD2, CD3
CO3	CD1

COURSE INFORMATION SHEET

Course code: MET25526
Course title: Disaster Management
Pre-requisite(s): B.Sc.
Co-requisite: -
Credits: 3 (L:3 T:0 P:0)
Class schedule per week: 3
Class: M.Sc.
Semester / Level: I/5
Branch: Environmental Science and Technology
Name of Teacher:

Course Objectives:
This course enables the students:

1.	To understand the basic concept of disaster management
2.	To characterise and classify the types of disasters and hazards
3.	To understand different mitigation and management plans
4.	To understand the basic concepts of roles and responsibilities
5.	To understand the disasters from the case studies

Course Outcomes:
After the completion of this course, students will be:

1.	Able to define and classify disasters and hazards
2.	Able to analyse the impacts of disasters over time
3.	Able to plan mitigation measures and recommend the modern tools and strategies required to manage the disaster

Syllabus

Module I **[8 Lectures]**

Definitions

Disasters, hazards, risk, vulnerability, resilience, disaster cycle, Prevention, mitigation, relief and response, recovery and rehabilitation, Management.
Natural and Man-made disasters, earthquakes, floods, drought, landslides, land subsidence, cyclones, volcanoes, tsunamis, avalanches, global climate extremes. accidents, leakages, waste disposal, oil spills, and forest fires.

Module II **[8 Lectures]**

Consequences and impact of disasters

Floods, cyclones, tsunamis, earthquakes, landslides, volcanic eruptions, desertification, drought, and salinity ingress. Hazards: Primary, secondary and tertiary effects. Social Economics and Environmental impact of disasters.

Module III **[8 Lectures]**

Mitigation and Management Techniques of Disaster

Disaster and its management; Disaster Management Structures, components, cycle, mitigation, risk reduction, mitigation plan, mitigation plan at national level, mitigation plan at international level, Contingency Plan, Emergency Planning, Risk assessment, Early warning signal and detection

Module IV **[8 Lectures]**

Role and Responsibilities

Role of the government, role of non-governmental organisation, role of citizen, state disaster response force, National disaster response force, role of media and social media, role of community, disaster responsibility, administrative responsibility, community action plan, disaster preparedness, rescue, rehabilitation, disaster recovery plan

Module V

Case studies **[8 Lectures]**

The National Disaster Management Plan, Biological and chemical disasters – epidemics, pandemics, industrial accidents. Case studies of disasters: earthquakes, landslides, cyclones, floods, droughts, volcanoes.

Books Recommended:

Textbooks:

1. A.K. Shrivastava, Textbook of Disaster Management, Scientific Publishers, 2024, ISBN: 9789389412451
2. Edward A Keller and Robert H Blodgett. 2008. Natural hazards. Pearson Prentice Hall.

Reference books:

1. National Disaster Management Authority, Government of India, https://ndma.gov.in/Resources/booklets
2. Disaster Management Guidelines, GOI-UND Disaster Risk Program (2009-2012)
3. Murthy D.B.N. (2012) Disaster Management, Deep and Deep Publication PVT. Ltd. New Delhi.
4. Modh S. (2010) Managing Natural Disasters, Mac Millan publishers India LTD.
5. Donald Hyndman and David Hyndman. 2009. Natural hazards and disasters. Brooks/Cole.
6. Gupta A.K., Niar S.S and Chatterjee S. (2013) Disaster management and Risk Reduction, Role of Environmental Knowledge, Narosa Publishing House, Delhi.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus. PO4, PO5 & PO6

Topics beyond the syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design.

Course Delivery Methods
Lectures by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training
Self, learning such as the use of NPTEL materials and internet
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Quiz Marks	30
Assignment	10
Seminar	10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3
Quiz Marks	3	3	3
End Sem Examination Marks	3	3	3
Assignment	3	3	3

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Mapping of Course Outcomes into Program Outcomes

Course Outcome	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
1	3	1	3	3	1	1
2	3	1	3	3	1	1
3	3	3	3	3	1	1

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery Methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lectures by use of boards/LCD projectors/OHP projectors		CO1, 2, 3,	CD1
CD2	Tutorials/Assignments		CO1, 2, 3	CD1
CD3	Seminars		CO1, 2, 3	CD1 and CD2
CD4	Mini projects/Projects			
CD5	Laboratory experiments/teaching aids			
CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self, learning such as the use of NPTEL materials and internet			
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: MET25527
Course Title: Advanced Water and Wastewater Treatment
Pre-requisite(s):
Co-requisite(s):
Credits: L:3 T:0 P:0
Class schedule per week: 3
Class: M. Sc.
Semester / Level: 5
Branch: Environmental Science and Technology
Name of Teacher:

Course Objectives
This course enables the students:

A.	To understand advanced wastewater treatment methods
B.	To learn the advanced techniques to treat wastewater to meet stringent disposal standards
C.	To understand the wastewater reclamation techniques

Course Outcomes
After the completion of this course, students will be:

1.	Able to assess the need for advanced water treatment schemes
2.	Able to choose the different physico-chemical, nutrient and other removal schemes
3.	Able to recommend the advanced technologies required to meet different standards

Syllabus

Module I **[8 Lectures]**
Introduction
Advanced wastewater treatment, the need for advanced wastewater treatment, methods of advanced water and wastewater treatment.

Module II **[8 Lectures]**
Nutrient removal from wastewater
Nitrogen & Phosphorus Removal: Nitrification, Denitrification Simultaneous nitrification and denitrification, Phosphorus Removal: Phosphorus removal by Chemical Precipitation, Chemistry of phosphorus precipitation, Process configuration, Phosphorus removal by Biological Precipitation, Microorganisms involved in the process, Process configurations

Module III **[8 Lectures]**
Physicochemical processes
Adsorption, Type of adsorbents, Development of adsorption isotherms: Freundlich, Langmuir, BET Activated carbon adsorption, Granular carbon adsorption. Ion Exchange, Types of Ion Exchange Resins, Theory of Ion Exchange Applications, Removal and recovery of heavy metals, Removal of nitrogen, Removal of phosphorus, Organic chemical removal

Module IV **[8 Lectures]**

Membrane Filtration

Membrane Process Classification, Microfiltration, Ultrafiltration, Nanofiltration, Reverse Osmosis, Electrodialysis Membrane Fouling, Application of membrane processes: Microfiltration, Ultrafiltration, Nanofiltration, Reverse Osmosis

Membrane Bio Reactor: MBR Process, MBR System Features Membrane Module, Process Applications: Industrial Wastewater Treatment, Municipal Wastewater

Module V **[8 Lectures]**

Electrochemical Treatment Processes

Electro-coagulation, Factors affecting Electrocoagulation, Electrode materials, Reactor configurations Electro-floatation: Factors affecting electro floatation Comparison with other technology, Reactor configurations Electro-oxidation: Electro oxidation process, Reactor configurations. Advanced Oxidation Processes: Theory of advanced oxidation, Types of oxidising agents, Fenton and photo-Fenton Oxidation Solar Photo Catalytic Treatment Systems

Textbooks:

1. Metcalf & Eddy (2003) Wastewater engineering: treatment and reuse, 4th ed. New Delhi: Tata McGraw-Hill.
2. Qasim, Syed R., Motley, Edward M., and Zhu, Guang (2000) Water works engineering: planning, design and operation. New Jersey: Prentice Hall.

Reference books:

1. Metcalf & Eddy (2006), Water Reuse: Issues, Technologies, and Applications, Edition 1, McGraw-Hill Professional Publishing
2. Mackenzie L Davis, 2010, Water and Wastewater Engineering, Edition 1, McGraw-Hill Professional Publishing
3. Nathanson, Jerry A. (2009) Basic environmental technology: water supply, waste management and pollution control, 4th ed. New Delhi: PHI Learning.
4. AMERICAN WATER WORKS ASSOCIATION, MANUAL, AWWA,
5. CPHEEO Manual on Sewerage and Sewage treatment, latest edition

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus.

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design.

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training
Self- learning such as use of NPTEL materials and internets
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Quiz Marks	30
Assignment	10
Seminar	10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3
Quiz Marks	3	3	3
End Sem Examination Marks	3	3	3
Assignment	3	3	3

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Outcomes into Program Outcomes

Course Outcome	Program Outcomes					
	1	**2**	**3**	**4**	**5**	**6**
1	3	3	3	3	1	1
2	3	3	3	3	1	1
3	3	3	3	3	1	1

COURSE INFORMATION SHEET

Course code: MET25528
Course title: INDUSTRIAL POLLUTION CONTROL (OPEN ELECTIVE/ PE)
Pre-requisite(s): Basic concepts of Environmental Science
Co- requisite(s): NA
Credits: 3 L:3 T:0 P:0
Class schedule per week: 3
Class: M.Tech.
Semester / Level: /5
Branch: All
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	To develop a comprehensive understanding of the types, sources, and characteristics of industrial pollution affecting air, water, and soil environments
2.	To analyze the causes and impacts of industrial pollution and to formulate appropriate mitigation, control, and site reclamation strategies.
3.	To understand the significance of occupational health and industrial safety measures in minimizing risks to workers and ensuring sustainable industrial operations.

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Identify and classify different types of industrial pollutants and understand their sources and characteristics
CO2	Analyze the environmental and health impacts of industrial pollution on ecosystems and human populations.
CO3	Evaluate and design effective pollution mitigation techniques and site reclamation measures for contaminated environments.
CO4	Understand and interpret the principles and practices of occupational health and industrial hygiene.
CO5	Apply industrial safety standards and develop risk management strategies to ensure worker safety and environmental compliance.

Syllabus (OPEN ELECTIVE)

Module I: Industrial Air Pollution

Overview of industrial pollution and major air pollutants; Sources and types of air pollutants from industries, Industrial emission control technologies: Mechanical (cyclones, filters), Chemical (scrubbers, absorbers), Thermal (afterburners, incinerators); Industrial air pollution disasters and key case studies, Air pollution laws and standards: The Air (Prevention and Control of Pollution) Act, 1981; CPCB guidelines

Module II: Industrial Water Pollution

Industrial water usage and characteristics of effluents; Major water pollutants, Impacts on

aquatic ecosystems and public health; Effluent Treatment Plants (ETPs): Primary, secondary, tertiary treatment processes and Advanced technologies, Industry-specific case studies, Legal framework: Water (Prevention and Control of Pollution) Act, 1974; zero liquid discharge (ZLD) concept

Module III: Industrial Solid Waste and Hazardous Waste Management
Classification of solid wastes: process wastes, hazardous wastes, biomedical, e-waste; Sources of industrial solid waste, Collection, storage, transportation, and disposal methods; Waste minimization strategies: reuse, recovery, recycling, co-processing; Treatment technologies: composting, incineration, landfilling, pyrolysis; Overview of waste-to-energy concepts; Regulatory policies: Hazardous Waste Management Rules (2016), Solid Waste Management Rules (2016), E-waste Rules (2022)

Module IV: Land Degradation and Control Measures
Types of land degradation caused by industrial activities: contamination, erosion, subsidence; Reclamation of degraded lands, Principles of cleaner production and industrial ecology; Sustainable industrial practices: waste audit, green belt development, eco-industrial parks; Case studies: ash pond reclamation, mining belt restoration, National policies and programs for land rehabilitation

Module V: Industrial Pollution Control Strategies and Legislation
Pollution control in specific sectors: cement, iron & steel, petroleum, fertilizer, tanneries; Role of Environmental Management Systems (EMS), ISO 14001; Introduction to Environment Impact Assessment (EIA) in industries; Legal provisions: Environment (Protection) Act, 1986, Public Liability Insurance Act, 1991, EIA Notification 2006, Role of CPCB, SPCBs, MoEFCC in enforcement

Books recommended:
TEXT BOOK

1. Introduction to Environmental Engineering – Gilbert and Masters v. Wastewater engineering: Metcalf & Eddy, et.al., Mcgraw Hill Pub. **(T1)**
2. Textbook of Environmental Sudies – by E. Bharucha. **(T2)**

REFERENCE BOOK

1. Handbook of Industrial pollution & Control- Vol 1 & 2, S. C. Bhatia, CBS Publishers. **(R1)**
2. Industrial waste treatment Handbook- Woodward and Cirran, Elsevier Pub **(R2)**
3. Industrial Pollution Control Handbook- Edited by Herbert, F. Lund, McGrawhill Pub **(R3)**

Gaps in the syllabus (to meet Industry/Profession requirements):

Topics beyond syllabus/Advanced topics/Design:

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS AND EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 (3 X 10)
Assignment(s)	10
Seminar before a Committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	3	3	2	3
CO2	1	1	3	3	2	2
CO3	1	1	3	3	2	2
CO4	1	2	1	1	1	1
CO5	2	3		3	2	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2
CO2	CD1, CD2
CO3	CD1, CD2
CO4	CD1, CD2
CO5	CD1,CD2
CO6	CD1, CD2
CO7	CD1, CD2

COURSE INFORMATION SHEET

Course code: MET25529
Course title: Environmental Biotechnology
Pre-requisite(s): B.Sc.
Co-requisite: -
Credits: 3 (L:3 T:0 P:0)
Class schedule per week: 3
Class: M.Sc.
Semester / Level: 5
Branch : Environmental Science and Technology
Name of Teacher:

Course Objectives:
This course enables the students:

1	To develop basic knowledge of environmental biotechnology
2.	To apply the knowledge acquired on environmental biotechnology in environmental quality monitoring and pollution control
3.	To know about various bioremediation processes
4.	To apply the environmental biotechnology developments for cleaner production

Course Outcome:
After the completion of this course, students will be:

CO1.	Understanding the basic concept of environmental biotechnology for applications in environmental protection
CO2.	Able to apply environmental biotechnology to develop solutions for air pollution control
CO3.	Able to know the importance of environmental biotechnology for environmental cleanup

Syllabus

Module I **[8 Lectures]**

Overview of Environmental Biotechnology:

Environmental Biotechnology - scope and importance. present status, enzyme technology and their environmental applications.

Module II **[8 Lectures]**

DNA Technology:

Concept of DNA technology, safety, social, moral and ethical aspects; applications of recombinant technology for enhanced biodegradation; detection of pathogens and parasites in wastewater

Module III **[8 Lectures]**

Air pollution Control Through Biotechnology:

Biotechnology in reduction of CO_2 emission, Bioscrubbers, Biobeds, Biotrickling filters and their applications.

Module IV **[8 Lectures]**

Bioremediation:

Types of bioremediation, Phytoremediation, Bioaugmentation, Bioreactors, Bioremediation of herbicides, pesticides, hydrocarbons, oil spills, metal removal processes

Module V **[8 Lectures]**

Cleaner Biotechnological Processes:

Biobleaching in pulp and paper industries; bioleaching, cleaner biotechnologies in agro-industries, biological fuel generation: biogas, hydrogen, methane and alcohol production

Books recommended:

TEXTBOOKS:

1. Microbial Biotechnology: A. N. Glazer and H. Nikaids
2. Molecular Biotechnology: Gleek and Pasternack
3. Biotechnology: A Textbook of Industrial Microbiology, T. D. Brock
4. Industrial Microbiology: Prescott and Dunn.

REFERENCE BOOKS:

1. Microbiology, Michael Pelczar Jr., ECS Chan, NR Kreig, Tata McGraw-Hill Education
2. Brock Biology of Microorganisms, Michael T. Madigan, John M. Martinko, Kelly S. Bender, Daniel H. Buckley, David A. Stahl, Thomas Brock

Gaps in the syllabus (to meet Industry/Profession requirements)

Application of real-life industrial problems

POs met through Gaps in the Syllabus: PO6

Real life experiments conducted in lab and large scale

POs met through Topics beyond syllabus/Advanced topics/Design: **PO5 and PO6**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS AND EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 (3 X 10)
Assignment(s)	10
Seminar before a Committee	10

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	1	1
CO2	3	2	2	1	1	1
CO3	3	3	3	2	1	1

Course Delivery methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between COs and Course Delivery (CD) Methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO 1, 2, 3	CD1, CD2
CD2	Tutorials/Assignments		CO 1, 2, 3	CD1, CD2
CD3	Seminars		CO 1, 2, 3	CD1, CD2, CD3
CD4	Mini projects/Projects			
CD5	Laboratory experiments/teaching aids			
CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self-learning, such as the use of NPTEL materials and the internet			
CD9	Simulation			

COURSE INFORMATION SHEET (OPEN ELECTIVE and PE)

Course code	**:**	MET25530
Course title	**:**	**Natural Resource and Management**
Pre-requisite(s)	**:**	**B.Sc.**
Co-requisite	**:**	**-**
Credits	**:**	**3 (L:3 T:0 P:0)**
Class schedule per week	**:**	**3**
Class	**:**	**M.Sc.**
Semester / Level	**:**	**I/5**
Branch	**:**	**Environmental Science & Technology**
Name of Teacher	**:**	

Course Objectives:

This course enables the students:

1	To develop a comprehensive understanding of the classification, distribution, and significance of natural resources.
2.	To familiarize students with ecological principles and sustainability concepts governing resource use and conservation.
3.	To equip students with tools and techniques for ecological restoration, climate change risk assessment, and environmental management.
4.	To evaluate the interlinkages between natural resource exploitation, climate change, and sustainability transitions.
5.	To build competence in applying regulatory, economic, and technical frameworks for sustainable resource governance and management.

Course Outcome:

After the completion of this course, students will be:

CO1.	Analyze the types, uses, and degradation causes of natural resources through ecological and sustainability principles.
CO2.	Evaluate ecological restoration strategies and develop community-inclusive rehabilitation plans for degraded ecosystems.
CO3.	Assess climate change impacts on natural resources using risk and vulnerability assessment tools, and interpret national policies.
CO4	Differentiate between renewable and non-renewable resources and propose sustainable extraction, reclamation, and transition pathways.
CO5	Apply environmental management tools (EIA, LCA, ISO 14001, etc.) to enhance sustainability in resource use and industry practices.

Syllabus

Module I

Natural Resources and Ecological Principles

Classification and importance of natural resources, Resource scarcity and degradation – causes and consequences, Ecosystem services and natural capital, Population and community ecology; carrying capacity, Principles of ecological sustainability, Laws of ecology and resource optimization.

Module II:

Ecological Restoration and Rehabilitation

Concept and need for ecological restoration, Passive vs. active restoration methods, Techniques for restoring degraded ecosystems (forests, grasslands, wetlands), Indicators for ecological monitoring and evaluation, Socioeconomic dimensions and community-based restoration, National Mission on Ecosystem Restoration (India-specific examples)

Module III:

Climate Change and Natural Resource Risk Assessment

Climate change science and IPCC framework, Impacts of climate change on soil, forests, minerals, and land productivity, Vulnerability and risk assessment of natural resources, Resource depletion under climate stress: heatwaves, droughts, floods; Carbon budgeting and climate-smart resource management; Natural hazard mapping, GIS tools, and early warning systems; India's National Action Plan on Climate Change (NAPCC) and resource missions (e.g., National Mission on Sustainable Agriculture, Green India Mission)

Module IV:

Mineral and Renewable Resource Management

Classification of mineral resources: fuel vs. non-fuel; Techniques of mineral extraction and their environmental implications, Mine reclamation, rehabilitation, and sustainable extraction practices; Renewable energy sources: solar, wind, biomass, geothermal; India's energy transition: missions, targets, and regulatory frameworks; Environmental impacts and life cycle emissions; Resource efficiency, energy audits, and circularity in practice.

Module V:

Sustainability and Environmental Management Tools

Concept and frameworks of sustainable development; Environmental impact assessment (EIA) and strategic environmental assessment (SEA); Corporate social responsibility (CSR) and sustainability reporting; Environmental management systems (EMS) and ISO 14001; Life cycle assessment (LCA) and material flow analysis; Circular economy principles and resource productivity; National and international environmental standards and protocols.

Books recommended:

TEXTBOOKS:

1. **Odum, E. P. & Barrett, G. W.** (2005). *Fundamentals of Ecology* (5th Edition). Thomson Brooks/Cole.
2. **Miller, G. T., & Spoolman, S.** (2020). *Living in the Environment* (19th Edition). Cengage Learning.
3. **Chiras, D. D.** (2013). *Environmental Science* (9th Edition). Jones & Bartlett Learning.
4. **UNEP.** (2012). *Global Environment Outlook (GEO-5): Environment for the Future We Want*. United Nations Environment Programme.
5. **Gadgil, M. & Guha, R.** (2000). *The Use and Abuse of Nature*. Oxford University Press.

REFERNCE BOOKs/MATERIALS:

1. **National Action Plan on Climate Change (NAPCC)** – Government of India Reports.
2. **IPCC Assessment Reports** (AR6 and earlier) – Intergovernmental Panel on Climate Change.
3. **India's State of Forest Reports (FSI)** – Forest Survey of India.
4. **MEA (Millennium Ecosystem Assessment)** – Ecosystems and Human Well-being: Synthesis.
5. **MoEFCC Guidelines on EIA & Ecological Restoration** – Ministry of Environment, Forest and Climate Change, Government of India.

Gaps in the syllabus (to meet Industry/Profession requirements)
Application of real-life industrial problems

POs met through Gaps in the Syllabus: PO6
Real life experiments conducted in lab and large scale
POs met through Topics beyond syllabus/Advanced topics/Design: **PO5 and PO6**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS AND EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	**% Contribution during CO Assessment**
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	**% Distribution**
3 Quizzes	30 (3 X 10)
Assignment(s)	10
Seminar before a Committee	10

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	1	3	2	2
CO2	1	2	1	2	3	1
CO3	1	3	1	3	2	3
CO4	1	2	1	3	1	2
CO5	1	3	1	2	2	2

Course Delivery methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between COs and Course Delivery (CD) Methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO 1, 2, 3	CD1, CD2
CD2	Tutorials/Assignments		CO 1, 2, 3	CD1, CD2
CD3	Seminars		CO 1, 2, 3	CD1, CD2, CD3
CD4	Mini projects/Projects			
CD5	Laboratory experiments/teaching aids			
CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self-learning, such as the use of NPTEL materials and the internet			
CD9	Simulation			