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 Management)

Programme Educational Objectives (PEOs)

PEO1: To impart students with a strong knowledge base through theory and sessional courses to work in industries, academics, research and consultancy.

PEO2: To enable the students to identify, analyze, and solve environmental problems.

PEO3: To enable the students to develop and execute feasible solutions to the diverse ecosystem challenges.

PEO4: To inculcate in student's sensitivity towards social and corporate responsibilities on environmental issues.

PROGRAMME OUTCOMES (POs)

PO1: An ability to independently conduct investigations and solve real-life ecological and environmental problems.

PO2: Students should be able to exhibit a wide degree of skill and attributes in environmental science and management.

PO3: Acquire a degree of mastery over the area as per the program's specialization. The mastery should be higher than the requirements in the appropriate Bachelor's program.

PO4: An ability to develop environmental impact assessment and monitoring, environmental management plan

PO5: An ability to write and present scientific documents (reports, journal articles, chapters, etc.)

PO6: Be able to critically evaluate environmental sustainability, sensitize communities through effective communications, and assess alternative solutions for adequate decision-making for overall environmental management.

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

Semester I

	Course Level	Course Code	Course Name	Delivery Method Lecture – L; Tutorial – T; Practical - P			Credits
				L	T	P	
Semester I	Program Core	ES501	Ecology and Biodiversity	3	0	0	3
	Program Core	ES502	Environmental Chemistry	3	0	0	3
	Program Core	ES503	Water and Wastewater Management	3	0	0	3
	Program Core	ES504	Sustainable Development	3	0	0	3
	Program Elective		PE I	3	0	0	3
	Open Elective		OE I/MOOC	3	0	0	3
	Program Core	ES505	Ecology and Biodiversity Laboratory	0	0	4	2
	Program Core	ES506	Water and Wastewater Analysis Laboratory	0	0	4	2
	Open Elective	MT132	Communication Skills I	0	0	3	1.5
						Total Credits	23.5

Semester II

	Course Level	Course Code	Course Name	Delivery Method Lecture – L; Tutorial – T; Practical - P			Credits
				L	T	P	
Semester II	Program Core	ES507	Earth Science	3	0	0	3
	Program Core	ES508	Solid Waste Management	3	0	0	3
	Program Core	ES509	Air Quality Management and Noise Pollution	3	0	0	3
	Program Core	ES510	Remote Sensing and GIS	3	0	0	3
	Program Elective		PE II	3	0	0	3
	Open Elective		OE II/MOOC	3	0	0	3
	Program Core	ES511	Air and Soil Pollution Monitoring Laboratory	0	0	4	2
	Program Core	ES512	Remote Sensing and GIS Laboratory	0	0	4	2
	Open Elective	MT133	Communication Skills II	0	0	3	1.5
	Program Core	ES513	Field Visit and Industrial Training	0	0	0	2
						Total Credits	25.5

Semester III

	Course Level	Course Code	Course Name	Delivery Method Lecture – L; Tutorial – T; Practical - P			Credits
				L	T	P	
Semester III	Program Core	ES514	Environmental Impact Assessment and Environmental Governance	3	0	0	3
	Program Core	ES515	Ecosystem Health and Restoration	3	0	0	3
	Program Core	ES516	Climate Change and Adaptation	3	0	0	3
	Program Core	ES517	Industrial Health and Safety	3	0	0	3
	Program Elective		PE III	3	0	0	3
	Program Core	ES518	Project Part I	0	0	8	8
						Total Credits	23

Semester IV

	Course Level	Course Code	Course Name	Delivery Method Lecture – L; Tutorial – T; Practical - P			Credits
				L	T	P	
Semester IV	Program Core	ES519	Project Part II	0	0	8	8
						Total Credits	8

Grand Total of Credits: 80

Program Electives:

MO Session:
ES520 Renewable Energy Resources
ES521 Environmental Economics
ES522 Environmental Biotechnology
ES523 Environmental Statistics

SP Session:
ES524 Environmental Toxicology
ES525 Instruments for Environmental Sample Analysis
ES526 Advanced Wastewater Treatment
ES527 Industrial Pollution Control

COURSE INFORMATION SHEET

Course code	**:**	**ES501**
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 & Management**
Name of Teacher	**:**	

Course objectives

This course enables the students to:

1	become conversant with the structural and functional attributes of ecosystem and environment.
2	be aware of the impact of climate change and pollution on its resources including biodiversity.
3	be able to critically analyze the natural ecological principles for sustainable development.

Course Outcomes:

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

CO1	conceptualize the structure and function of ecosystem and to be able to determine the ecosystem characteristics on field.
CO2	analyze population dynamics, including growth patterns, species interactions, and environmental influences.
CO3	evaluate the structure, dynamics, and interactions within ecological communities.
CO4	assess the significance, measurement, and conservation of biodiversity across different ecosystems.
CO5	apply ecological concepts to address environmental issues and inform sustainable practices.

Syllabus

Module I **[8 Lectures]**

Basics of Ecology:

Origin of Life, Levels of Organisation, Introduction to Ecology, Structure and Functions of Ecosystems- Abiotic and Biotic components, Ecological energetics, Energy and material cycling. Productivity, Species interactions, Exposure to different types of ecosystems.

Module II **[8 Lectures]**

Population Ecology:

Population characteristics, Demographic parameters - Migration, Mortality, Natality, Biotic potential, fecundity and age structure, survivorship schedules, Phenograms, Population growth patterns: exponential and logistic, 'r' and 'k' selection of species.

Module III **[8 Lectures]**

Community Ecology:

Community characteristics, composition. Qualitative and quantitative characters, community classifications, methods of studying vegetation; survey and assessment of frequency, abundance, dominance etc., Diversity indices, Ecological succession

Module IV **[8 Lectures]**

Biodiversity:

Biodiversity – Basic concepts of biodiversity, Biodiversity- definition, levels and types, Biodiversity of Indian subcontinent: biodiversity hotspots, their characteristic flora and fauna, Biodiversity conservation strategies: in situ conservation, in vitro conservation, Indian initiatives in biodiversity conservation, international programmes for biodiversity conservation, Policy, Law and International Conventions in Biodiversity Management

Module V **[8 Lectures]**

Applications of Ecological Principles:

Ecosystem response to environmental contamination (deoxygenation, eutrophication). Principles of Biomagnification and Biotransformation, Biomonitoring – a tool for environmental monitoring, Ecological restoration – from theory to practice, Phytoremediation and bioremediation of environmental contaminants.

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
CO3	CD1, CD2, CD6, CD7
CO4	CD1, CD3, CD6, CD7
CO5	CD1, CD2, CD3,CD7

COURSE INFORMATION SHEET

Course code	**:**	**ES502**
Course title	**:**	**Environmental Chemistry**
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 & Management**
Name of Teacher	**:**	

Course Objectives:

This course enables students to

1	Describe the fundamentals of environmental chemistry
2	Explain the concepts related to chemical processes in 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 practice of environmental science and management.
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, stoichiometry, enthalpy, chemical equilibria, environmental transformation, and degradation processes. Reaction kinetics, Bio-geochemical cycles.

Module II **[8 Lectures]**

Atmospheric 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, aerosols & atmosphere.

Module III **[8 Lectures]**

Aquatic Chemistry: Physico-chemical properties of water, organic components in natural waters, estuarine and ocean chemistry, water pollution – deoxygenation, DO & BOD, eutrophication, Eh-pH diagram, chemical speciation.

Module IV **[8 Lectures]**

Soil Chemistry: Chemical composition of soil, acid, base and ion exchange reactions, soil acidity, salinity and sodicity, sources and chemical nature of soil contaminants, important environmental properties of soil, distribution of soil contaminants: soil – water partition process, soil- organism processes, ecological and health effects of soil contaminants.

Module V **[8 Lectures]**

Environmental Monitoring and Assessment: Sampling of water, wastewater, soil and sediments, environmental samples analysis - gravimetric and volumetric methods, spectroscopic techniques, chromatographic techniques.

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

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" Use by APHA, AWWA, & WPCF

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	**:**	**ES503**
Course title	**:**	**Water and Wastewater 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 & Management**
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 application

Course Outcomes:

After the completion of this course, students will be:

1.	Able to assess the water quality and their 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 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 its 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, 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 utilisation

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 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	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	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	Lecture 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	**:**	**ES504**
Course title	**:**	**Sustainable Development**
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 & Management**
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	Knowledge of sustainable practices in various sectors, including energy, water, and agriculture.
3	Insights into the policy framework and international agreements influencing sustainable development.
4	Analytical tools to assess the social, economic, and environmental impacts of development projects.
5	Practical strategies to implement sustainable practices in both professional and personal settings.

Course Outcomes:

CO1	Understand the historical evolution, concepts, and pillars of sustainable development.
CO2	Identify the role of international agreements and policies in shaping sustainable development
CO3	Analyze the social, economic, and environmental impacts of various development initiatives.
CO4	Recognize sustainable practices in critical sectors and understand how to implement them effectively.
CO5	Develop strategies for promoting sustainable practices in organizations and communities.

Syllabus

Module I **[8 Lectures]**

Introduction to Sustainable Development:

Historical evolution, Brundtland Report, Sustainable Development Goals (SDGs), principles of sustainable development, challenges, and opportunities.

Module II **[8 Lectures]**

Policies and International Agreements:

UN agreements (Agenda 21, Paris Agreement), national policies, the role of NGOs and civil society, environmental ethics, and environmental justice.

Module III **[8 Lectures]**

Sustainability in Sectors:

Energy (renewable vs. non-renewable), water management, sustainable agriculture, waste management, sustainable cities, and biodiversity conservation.

Module IV **[8 Lectures]**

Impact Assessment and Measurement:

Environmental impact assessment, social and economic impact assessment, life cycle assessment, carbon footprint analysis, and sustainable indicators.

Module V **[8 Lectures]**

Implementation Strategies and Case Studies:

Green businesses, circular economy, community-driven sustainability projects, corporate social responsibility, stakeholder engagement, and behavior change.

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.

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

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	**:**	**ES505**
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 & Management**
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	**:**	**ES506**
Course title	**:**	**Water & 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 & Management**
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 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 phosphate in water
9. Determination of sulphate in water and wastewater
10. Coliform count of water and wastewater samples by 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
3. Introduction to Environmental Engineering and Science, G.M. Masters & Wendell Ela, PHI Publishers

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	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 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			
End Sem Examination Marks			
Assignment			

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			

COURSE INFORMATION SHEET

Course code	**:**	**ES520**
Course title	**:**	**Renewable Energy Sources**
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 & Management**
Name of Teacher	**:**	

Course Objectives

This course enables the students to:

1	Gain knowledge about the energy scenario of the world and understand the importance of renewable energy sources
2	Know the facts and information about the various renewable and non-conventional energy sources
3	Realize the potential of renewable energy resources globally and in India for a sustainable future

Course Outcomes

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

CO1.	compare and evaluate various energy sources and their environmental impacts.
CO2.	critically know the design parameters and potential of solar energy
CO3	know wind energy systems for effective and sustainable power generation.
CO4	Understand the mechanism and processes of geothermal and ocean energy options
CO5	Understand the principles, processes and application of energy from biomass.

Syllabus

Module I **[8 Lectures]**

Conventional and Non-Conventional Energy:

World energy sources and their classification, Renewable energy potential of India, Fossil fuels - past, present & future, Trends in new non-conventional energy sources.

Module II **[8 Lectures]**

Solar Energy:

Introduction, storage of solar thermal energy, solar window, flat plate collectors and concentrating collectors, Installation of flat plate collectors, performance analysis, the effect of various parameters on collector performance, applications of solar energy.

Module III **[8 Lectures]**

Wind Energy:

Introduction, wind characteristics, air density, power in the wind, wind turbines, Lift and drag, Types of the rotor, wind energy extraction.

Module IV **[8 Lectures]**

Geothermal and Ocean Energy:

Structure of earth's interior, plate tectonic theory, Geothermal gradients and resources, geothermal power generation, Indian scenario of geothermal energy; Principle of ocean thermal energy conversion systems

Module V **[8 Lectures]**

Energy from Biomass

Introduction, Biomass resources, biofuels, biogas technology, producer gas, liquid fuel, biochemical conversion, biomass gasification, energy recovery from urban waste, power generation from landfill, biodiesel.

Books recommended:

TEXTBOOKS:

1. Renewable energy sources and emerging technologies by D.P. Kothari, K.C. Singal and Rakesh Ranjan, PHI learning private ltd.
2. Non-conventional energy sources by G.D. Rai, Khanna publishers
3. Energy conservation and management by S. s. Thipse, Narosa publication
4. Alternate Energy Sources, Applications and Technologies by N.K. Giri, Khanna Publishers; First edition (2012)
5. Renewable Energy Resources for Sustainable Development, by A.M. Omer, Discovery publishing house (2017)

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

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

Topics beyond syllabus/Advanced topics/Design:

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	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	1	1	1	2
CO2	3	2	1	2	2	2
CO3	3	1	1	2	2	2
CO4	3	2	1	2	2	2
CO5	3	2	2	2	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	**:**	**ES521**
Course title	**:**	**Environmental Economics**
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 & Management**
Name of Teacher	**:**	

Course Objectives:

This course enables the students to:

1	To introduce the necessity of natural and ecological resources and their management in terms of economic values.
2	Conservation of ecological resources and study of their economics.
3	Students will learn the concepts and theories related to environmental economics
4	To learn about different recent initiatives and guidelines for environmental economics.

Course Outcomes:

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

CO1	Justify the necessity of natural resource conservation
CO2	The energy flow within different trophic levels of the ecosystem
CO3	Able to relate environmental degradation to the economy
CO4	Assist in decision-making in terms of resource valuation and conservation
CO5	understand the role of different bodies in controlling pollution

Syllabus

Module I **[8 Lectures]**

Historical Development of Environmental Economics:

The Environment-Economy Interaction, the Materials Balance Model and laws of Thermodynamics; Basic concepts of resource economics; natural capita and equity. Economic principles: Introduction to microeconomic theory covering theories and applications of individual and market demand, as well as production economics. Welfare economics and its application to imperfect competition and factor markets.

Module II **[8 Lectures]**

Pollution as an Economic Problem:

Market Failure, Externality, Exaction, Insertion, Social Trap; Alternative Definitions of Pollution; Optimal Pollution: Marginal Damage and Marginal Abatement Cost. Introduction to environmental economics and policy:

Essential economic concepts and theory relevant to environmental issues. Economic theories of pollution and management of natural resources. The impact of macroeconomic policies on the environment and the role of international environmental agreements on transboundary issues.

Module III **[8 Lectures]**

Instruments of Pollution Control:

Command and Control and Economic Instruments; International Agencies and Environment: UNEP, UNFCC. Environmental Values beyond use value: Environmental Resources and Market Failure, Signals of Natural Resource Depletion/ Scarcity (Direct and Indirect Approaches and their Limitations).

Module IV **[8 Lectures]**

Environmental Valuation; Concept of Total Economic Value, Uncertainty and Irreversibility, Economic growth and environment: Fundamentals of Environmental Kuznets Curve, Approaches to Environmental Valuation**:** Cost- Benefit/ Social Cost-Benefit Analysis, Health Cost Approach, Travel Cost Approach, Amenities and Hedonic Pricing, Contingent Valuation Methods: Revealed and Stated preferences, Willingness to pay and Willingness to Accept.

Module V **[8 Lectures]**

Natural Resource Economics:

Economic models of natural resource allocation and demonstrate their application to policy making and natural resource management to provide useful insights to both policy makers and managers. Application of Environmental Economics in Public Policy and Natural Resource management: Forest, Water, Fisheries and Pollution Management: key issues and options.

Books recommended:

TEXTBOOKS:

1. Hanley, N., J. Shogren, and B. White (1997): Environmental Economics in Theory and Practice, Macmillan Press. (T1)
2. Pearce, D. W., and R. K. Turner (1990): Economics of Natural Resources and the Environment, Harvester Wheatsheaf, London. (T2)
3. Perman, R., Y. Ma, J. McGilvray, and M. S. Common (1999), Natural Resources and Environmental Economics, 2nd Edition, Longmans. (T3)

REFERENCE BOOKS:

1. Values for the Environment: A Guide to Economic Approach – Winpeny JT, Overseas Development Institute, London, HMOS, 1991. (**R1**)
2. Economic Analysis of Environmental Impacts – Dixon, John, A, Scura LF, Carpenter RA and Sherman PB, Earthscan Publications Ltd., London 1995. (R2)

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

Topics beyond syllabus/Advanced topics/Design:
Environmental regulation and corruption,
Basic statistics and operation research concepts

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	3	2	1	2	2	1
CO2	3	2	1	1	1	1
CO3	3	3	2	1	2	2
CO4	3	3	3	2	3	2
CO5	3	3	3	3	2	2

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code	**:**	**ES522**
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	**:**	**I/5**
Branch	**:**	**Environmental Science & Management**
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 Outcomes:

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 Text Book of Industrial Microbilogy, 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

Course code	**:**	**ES523**
Course title	**:**	**Environmental Statistics**
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 & Management**
Name of Teacher	**:**	

Course Objectives

This course enables the students to:

1	Develop a general understanding of environmental statistics.
2	Identify the areas of application of statistics in Environmental Science and Engineering.
3	Apply the knowledge of statistical ideas and tools 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 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.
CO5.	Able to identify the components of statistical data structure needed for various environmental data collection.

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 Measures of Central Tendency:

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

Module III **[8 Lectures]**

Sampling Theory and Estimation Theory:

Hypothesis testing and interval estimation for large samples, Chi-square test, t- test and F test of significance, goodness of fit, Estimators: Unbiasedness, Consistency, Efficiency and Sufficiency – Maximum Likelihood Estimation, Interval estimation of parameters.

Module IV **[8 Lectures]**

Correlation and regression and Analysis of Variance:

Multiple and Partial Correlation, Correlation analysis: graphical analysis, covariance, correlation coefficient, distribution of correlation coefficient and its statistical significance. Empirical model building-Regression analysis: assumptions and definitions, principle of least squares, regression parameters their distribution and statistical significance; Analysis of variance – One-way and two-way Classifications.

Module V **[8 Lectures]**

Environmental Applications and Components of Statistical Data:

Environmental applications and components of statistical data on Environmental Conditions and Quality like Ecosystems and Biodiversity, Extreme Events and Disasters, Human Settlements and Environmental Health, Climate change, Agriculture.

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.

REFERENCE BOOKS:

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

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

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

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	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