National Institute of Technology Durgapur

Revised Curriculum and Syllabi

Program Name

Master of Technology
in
Environmental Science and Technology
Effective from the Academic Year: 2021-2022

(Curriculum and syllabus has been framed keeping in view the multidisciplinary nature of the discipline)

Participating Departments:

Dept. of Earth and Environmental Studies (Coordinating Department)

Dept. of Chemistry

Dept. of Civil Engineering

Dept. of Biotechnology

Recommended by DAC	: 07.08.2021
Recommended in PGAC	: 16.08.2021
Approved by the Senate	: 22.08.2021

Semester - I							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	ES1001	Fundamentals of Environment	3	0	0	3	3
2	ES1002	Environmental Chemistry	3	1	0	4	4
3	ES1003	Treatment of Water and Wastewater	3	1	0	4	4
4	XX903X	SPECIALIZATION ELECTIVE - I	3	0	0	3	3
5	XX903X	SPECIALIZATION ELECTIVE - II	3	0	0	3	3
6	ES1051	Environmental Analysis (Sessional)	0	0	4	2	4
7	ES1052	Microbiology and Wastewater Engineering Practical	0	0	4	2	4
		TOTAL	**15**	**2**	**8**	**21**	**25**
		Semester - II					
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	ES2001	Air and Noise pollution Quality and Control	3	1	0	4	4
2	ES2002	Solid Waste Management	4	0	0	4	4
3	XX903X	SPECIALIZATION ELECTIVE - IV	3	0	0	3	3
4	XX903X	SPECIALIZATION ELECTIVE - V	3	0	0	3	3
5	XX903X	SPECIALIZATION ELECTIVE - VI	3	0	0	3	3
6	ES2051	Air and Noise monitoring and analysis	0	0	4	2	4
7	ES2053	Remote Sensing & GIS Practical	0	0	4	2	4
		TOTAL	**16**	**1**	**8**	**21**	**25**
		Semester - III					
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	XX907X	AUDIT LECTURES / WORKSHOPS	0	0	0	0	2
2	ES3051	DISSERTION - I / INDUSTRIAL PROJECT	0	0	24	12	24
3	ES3052	SEMINAR - NON-PROJECT	0	0	4	2	4
		TOTAL	**0**	**0**	**28**	**14**	**30**
		Semester - IV					
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	ES4051	DISSERTION - II / INDUSTRIAL PROJECT	0	0	24	12	24
2	ES4052	PROJECT SEMINAR	0	0	4	2	4
		TOTAL	**0**	**0**	**28**	**14**	**28**
Summary							
		Subject	**L**	**T**	**S**	**C**	**H**
		I	15	2	8	21	25
		II	16	1	8	21	25
		III	0	0	28	14	30
		IV	0	0	28	14	28
		Grand Total	31	3	72	70	108

ELECTIVES FOR SEMESTER – I

Sl No	Subject Code	Subject
1.	ES9011	Mining and the Environment
2.	ES9012	Environmental Geology
3.	ES9013	Remote sensing and GIS
4.	ES9014	Green Chemistry / Technology

ELECTIVES FOR SEMESTER II

Sl No	Subject Code	Subject
1.	ES9015	Hydrogeology and Watershed Management
2.	ES9016	Natural Hazards and Disaster Management
3.	ES9017	Environmental Management
4.	ES9018	Noise control Engineering
5.	ES9019	Mathematical Modelling in Environmental Engineering
6.	ES9020	Environmental Radio-chemistry
7.	ES9021	Environmental Biotechnology
8.	ES9022	Hydro-geochemistry, Contamination and Remediation

COMPULSORY COURSES

<table>
<tr><td colspan="8">Department of Earth and Environmental Studies</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ES1001</td><td>Fundamentals of Environment</td><td>Program Core (PCR)</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Understand the importance of environment, ecosystem and the scientific basis of microbiology.
• CO2: Understand the fundamental aspect of pollutant tracking and its implementation in natural and anthropogenic pollution of air and water system.
• CO3: Interpret the use of microbiology in wastewater and drinking water treatment.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module 1: Environment as an idea, Environmental interrelationship, Environmental ethics.; Earth as a system – systems & feedbacks, Environmental unity, Uniformitarianism; Changes and equilibrium in systems, Ecology & Ecosystem, Biodiversity, The biogeochemical cycles; Segments of environment of earth – Atmosphere, Lithosphere, Hydrosphere and Biosphere. [07]
Module 2: Materials balance; Mathematics of Growth; Energy and Environment; Current environmental issues. [13]
Module 3: Fundamentals of microbiology; Degradation or Monitoring of pollutants from a Biological origin ; Microbes and Metabolism, Microbial diversity, Metabolic pathways of particular relevance to Environmental Biotechnology; Viruses, Bacteria, and Fungi. [10]
Module 4: Biological systems in Environment: Extremophiles, Thermophiles, Xenobiotics; Microbiology of wastewater treatment, Biotechnology in wastewater treatment. [10]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Microbiology, Michael J Pelczar Jr, ECS Chan, Noel R Kraig, 5th edition, 2001, Publisher : McGraw Hill Education,
Reference Books:
1. Introduction to Environmental Engineering and Science, Gilbert M Masters & Wendell P Ela, 3rd Edition, June 2015, Publisher : PHI Learning, ISBN-10: 9332549761, ISBN-13: 9789332549760
2. Fundamentals of Ecology, Eugene P Odum, 5th Edition, July 2004, Publisher: Cengage Learning, ISBN-10: 0534420664, ISBN-13: 978-0534420664</td></tr>
</table>

	Program Outcomes			
	PO1	**PO2**	**PO3**	**PO4**
CO1	**3**	**1**	**2**	**1**
CO2	**3**	**2**	**3**	**2**
CO3	**1**	**1**	**2**	**3**

<table>
<tr><td colspan="8">Department of Earth and Environmental Studies</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ES1002</td><td>Environmental Chemistry</td><td>Program Core (PCR)</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Understand the significance of different environmental pollutant and its kinetics.
• CO2: Demonstrate the knowledge about different Principles and application of analytical techniques as well as important instrument for chemical analysis.
• CO3: Understand the specific aspects biochemical and speciation, the nature and environmental chemistry of hazardous wastes and industrial ecology for waste minimization as well as toxicological chemistry of various classes of chemical substances.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module 1: Natural and anthropogenic sources, inorganic pollutants (SO, NOx, CO, CO2, hydrocarbon, SPM). Classification of elements, particles, ions, radicals in the atmosphere. [10]
Module 2: Chemical processes for formation of inorganic and organic particulate matter.; Toxic chemicals in the environment (pesticides, insecticides, carbon monoxide, ozone, PAN, MIC, PAH, carcinogens). [12]
Module 3: Principles and application of analytical techniques – titrimetry, gravimetry, Solvent extraction, colorimetry, spectrophotometry, chromatography, gas chromatography, HPLC, GC-MS, atomic absorption spectroscopy, ICP-AES, flame photometry, electrophoresis, X-ray fluorescence, X-ray diffraction; Stoichiometry. [10]
Module 4: Gibbs energy, chemical potential, chemical equilibria, acid base reactions, buffers and buffer index, pE-pH diagrams, redox potential, solubility product, solubility of gases in water, the carbonate system. [10]
Module 5: Biochemical and speciation aspects of Arsenic, cadmium, lead and mercury. [10]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
2. Solutions Manual for Environmental Chemistry, Colin Baird and Michael Cann, Publisher: W. H. Freeman; 5th edition (May 7, 2012),
3. Chemistry Fundamentals: An Environmental Perspective. Phyllis Buell and James Girard Publisher: Jones & Bartlett Publishers; 2nd edition (April 2002).
Reference Books:
1. Elements of Environmental Chemistry,Ronald A. Hites&Jonathan D. Raff,Publisher: Wiley; 2nd edition (April 24, 2012)
2. Chemistry for Environmental Engineering and Science,Clair Sawyer , Perry McCarty& Gene Parkin,Publisher: McGraw-Hill Education; 5th edition.</td></tr>
</table>

	Program Outcomes			
	PO1	**PO2**	**PO3**	**PO4**
CO1	**2**	**1**	**1**	**2**
CO2	**3**	**3**		**2**
CO3	**1**	**3**	**1**	**2**

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ES1003</td><td>Treatment of Water and Wastewater</td><td>Program Core (PCR)</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Understand the importance of raw/source water treatment, characterization of wastewater, treatment objectives, influence the type, number & sequence of unit operations and processes and the water and wastewater standards & regulations.
• CO2: Understand the fundamental, scientific basis governing the design and performance of the treatment unit and operations reviewed in the module.
• CO3: Design of water and wastewater treatment unit for the treatment of a typical raw/source water and a wastewater.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module 1: Drinking water standards and wastewater characteristics, Sources of water pollution: groundwater and surface water. Treatment options and selection of appropriate methods; Physico-Chemical treatment: Screening, Flow equalization, Filtration, Coagulation, Flocculation and settling, Chemical precipitation, Sedimentation, Design of Flocculator, settler. [20]
Module 2: Biological treatment: Fundamental of biological treatment process; Activated sludge process – basics of operation and trouble shooting, Design of activated sludge treatment system. [10]
Module 3: Trickling filter: Basic operation and trouble shooting, Designing Trickling filter system, Anaerobic sludge blanket system: Operation and Principle; Sludge disposal and treatment; Nutrients Removal from wastewater. [10]
Module 4: Ion-exchange; Disinfection of water; Membrane separation; Adsorption. [12]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Wastewater Engineering-Treatment and Reuse. Metcalf & Eddy, 4th Edition, McGraw-Hill, 2003; Publisher: McGraw-Hill Science/Engineering/Math
Reference Books:
1. Fundamentals of Water Treatment Unit Processes: Physical, Chemical, and Biological. David Hendricks. Publisher: CRC Press/ IWA Publishing, 2011;
2. Environmental Engineering. Howard Peavy, Donald Rowe, George Tchobanoglous Publisher: McGraw Hill Education (India) Private Limited; First edition (1 August 2013)</td></tr>
</table>

	Program Outcomes			
	PO1	**PO2**	**PO3**	**PO4**
CO1	**3**	**1**		
CO2		**3**	**1**	
CO3	**3**	**3**	**2**	**2**

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ES1051</td><td>Environmental Analysis</td><td>Program Core (PCR)</td><td>0</td><td>0</td><td>4</td><td>4</td><td>2</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="4">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="4">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">• CO1: Understand the significance of soil, water and water quality parameters and characterization of water, wastewater and soil.
• CO2: Demonstrate the idea about the soil, water and waste water quality standards and regulations.
• CO3: Understand the fundamental, scientific basis, preparation of sample, colorimetric analysis, sampling method.</td></tr>
<tr><td>Topics Covered</td><td colspan="6">Module 1: Analysis of water and water quality parameters- Concept of pH, Measurement of acidity, alkalinity [06]
Module 2: Measurement of hardness, residual chlorine, chlorides. [06]
Module 3: Phosphate-P, Sulphate, turbidity, phenol, cyanide, Different form of nitrogen, Nitrate. [12]
Module 4: Analysis of Soil: soil pH, Organic carbon, Chromium, Iron and other essential parameters. [12]
Module 5: Demonstrate and application of HPLC, GC and AAS etc. [06]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="6">Text Books:
1. Wastewater Engineering-Treatment and Reuse. Metcalf & Eddy, 4th edition, McGraw-Hill, 2003; Publisher: McGraw-Hill Science/Engineering/MathISBN-13: 978-0070418783, ISBN-10: 0070418780.
Reference Books:
3. Practical Environmental Analysis. Miroslav Radojevic & Vladimir N. Bashkin, Publisher: Royal Society of Chemistry; 2nd edition (April 26, 2006),ISBN-10: 0854046798, ISBN-13: 978-0854046799
4. Practical Manual of waste water chemistry. Barbara A. Hauser, Publisher: CRC Press, 1st edition (June 1, 1996).ISBN-10: 1575040123 ISBN-13: 978-1575040127</td></tr>
</table>

	Program Outcomes			
	PO1	**PO2**	**PO3**	**PO4**
CO1	**1**	**1**	**2**	**3**
CO2	**2**	**3**	**2**	**2**
CO3	**1**	**1**	**3**	**2**

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ES1052</td><td>Microbiology and Wastewater Engineering Practical</td><td>Program Core (PCR)</td><td>0</td><td>0</td><td>4</td><td>4</td><td>2</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">• CO1: Impart the knowledge on water and waste water standards and regulations and capable to determine the microorganisms present in wastewater and Soil.
• CO2: Evaluate different physicochemical and biological parameters that are useful in water and wastewater treatment processes.
• CO3: Understand the fundamental, scientific basis governing the design and performance of the water and wastewater treatment unit and operations reviewed in the module.</td></tr>
<tr><td>Topics Covered</td><td colspan="6">Module 1: Microbiology Lab:
1. Isolation and enumeration and characterization of microorganisms from wastewater sample by serial dilution – agar plating method.
2. Bacteriological examination of water by multiple-tube technique (or MPN test)
3. Isolation, enumeration and characterization of microorganisms from industrial sludge by serial dilution –agar plating method. [20]
Module 2: Wastewater Lab:
1. Evaluation of Activated Sludge process through useful parameters like MLSS, MLVSS, SVI, HRT, N/P RATIO, DO, BOD, COD, Specific pollutants, calculation of treatment efficiency.
2. Design of Activated Sludge Process. [20]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="6">Text Books:
1. Wastewater Engineering-Treatment and Reuse. Metcalf & Eddy, 4th edition, McGraw-Hill, 2003; Publisher: McGraw-Hill Science/Engineering/Math
Reference Books:
5. Practical Environmental Analysis. Miroslav Radojevic& Vladimir N. Bashkin, Publisher: Royal Society of Chemistry; 2nd edition (April 26, 2006),ISBN-10: 0854046798, ISBN-13: 978-0854046799
6. Practical Manual of waste water chemistry. Barbara A. Hauser,Publisher: CRC Press, 1st edition (June 1, 1996).</td></tr>
</table>

	Program Outcomes			
	PO1	**PO2**	**PO3**	**PO4**
CO1	**1**	**1**	**3**	**2**
CO2	**2**	**3**	**2**	**2**
CO3	**1**	**2**	**3**	**3**

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ES2001</td><td>Air and Noise Pollution Quality and Control</td><td></td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Understand how to assess the existing air quality and the extent of noise pollution.
• CO2: Understand the fundamental, scientific basis governing the design and performance of the equipment used for air and noise pollution control and operations reviewed in the module.
• CO3: Design of air and noise pollution controlling devices used at industrial as well as domestic level.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module 1: Air qualities and their pollution parameters; Sampling and measurement of air pollution parameters: Ambient air sampling, Stack sampling, Monitoring equipment, Analysis of air pollutants. Meteorology of Air pollution control: Solar radiation, Heat balance, Wind velocity, Turbulence, Wind profile, Humidity, Temperature; Atmospheric stability: Lapse rate, Inversion, Plume shape, Maximum mixing depth, Air pollution dispersion modelling, General ideas in Air Pollution Control. [16]
Module 2: Air pollution control methods, equipment, design and engineering: Particulate emission control – Gravity settling chamber, Cyclone separator, ESP, Bag filter, Venturi scrubber. [12]
Module 3: Control of gaseous emission; Control of gaseous pollutants – Control of VOC, Control of NO_X, Control of SO_X, Control of CO & CO_2; Pollution from mobile sources, problems, effects, testing and control, preventive measures. [16]
Module 4: Noise – sources, measurements, effects and occupational hazards, Standards, Noise mapping, Noise attenuation, Prediction equations, Control measures, Legal aspects of noise. [10]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Environmental Engineering, M. L. Davis and D. A. Cornwell; 3rd Edition WCB/McGraw-Hill;
2. Environmental Engineering. Arcadio P. Sincero and Gregoria A. Sincero; 1st Edition (August 18, 1995), Publisher: Prentice Hall;
Reference Books:
1. Environmental Pollution Control Engineering. C.S. Rao; 2nd Edition, Publisher: New Age International, 2006;
2. Air Pollution Control Equipment. H. Brauer and Y. B. G. Verma; Latest Edition; Publisher: Springer, 1981;</td></tr>
</table>

	Program Outcomes			
	PO1	**PO2**	**PO3**	**PO4**
CO1	**2**		**1**	
CO2	**1**		**3**	**1**
CO3	**3**		**2**	**3**

<table>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ES2002</td><td>Solid waste Management</td><td></td><td>4</td><td>0</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Get good insight into the current environmental and health problems caused by inadequate solid waste management.
• CO2: Acquire strategies and approaches to resolve these problems as a best public health functionary.
• CO3: Understand modern treatment technologies and regulations as well as sustainability of the chosen technology.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module 1: Solid waste sources: Industrial, Mining, Agricultural and Domestic (Urban) wastes. Municipal solid waste management: Waste generation, collection, storage, transfer, treatment and disposal; MSWM Rules. [09]
Module 2: Solid waste characterization and reduction, reuse and recycling, resource recovery and utilization; Life cycle assessment of waste. [05]
Module 3: Processing of MSW: Unit operations; Segregation; Shredding and screening plastic waste, refuse derived fuel composting biofuel production; incineration and energy recovery. [12]
Module 4: Landfill design and operation: site selection, design and operations, equipments, costs, liner and covers, leachate control and treatment, gas recovery and control, landfill monitoring and reclamation; Incinerator. Biomedical waste categorization, generation, collection, transport, treatment and disposal. [08]
Module 5: Hazardous waste: Characteristics including classification and generation, Collection, Treatment, Monitoring, Disposal; Remediation of contaminated sites; Radioactive waste management. [06]
Module 6: E-Waste Management: Definition of e-waste; Classification of e-waste; Indian Scenario; e waste management rules, 2011. [04]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Solid and Hazardous Waste Management. S.C. Bhatia, Publisher: Atlantic Publishers & Distributors (P) Ltd., 2007.
2. Sincero, Arcadio Pacquiao, and Gregoria Alivio Sincero. "Environmental Engineering: A design approach." (1996).
Reference Books:
1. Integrated Solid Waste Management: Engineering Principles And Management Issues. George Tchobanoglous, Hilary Theisen, Samuel Vigil, Tata McGraw-Hill publisher.
2. Solid and Hazardous Waste Management, M.N. Rao, Razia Sultana,
3. Nuclear and Hazardous Waste Management, N.K. Malhotra, Publisher: Neha Publishers & Distributors, ISBN 10:8184201060, 13:9788184201062.</td></tr>
</table>

	Program Outcomes			
	PO1	**PO2**	**PO3**	**PO4**
CO1	**1**	**2**	**3**	**2**
CO2	**1**	**1**	**2**	**3**
CO3	**1**	**1**	**3**	**2**

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ES2051</td><td>Air and Noise Monitoring and Analysis</td><td>Program Core (PCR)</td><td>0</td><td>0</td><td>4</td><td>4</td><td>2</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">• CO1: Understand natural scavenging or cleansing process undergoing in the environment through pollution, dilution, dispersion, wind movement, dry deposition, precipitation and chemical transformation of pollutants generated.
• CO2: Plan and efforts to be executed nation-wide for the prevention, control and abatement of air and noise pollution.
• CO3: Demonstrate the air and noise monitoring standards and regulations.</td></tr>
<tr><td>Topics Covered</td><td colspan="6">Module 1: Demonstration of air pollution monitoring instruments; Determination of SPM, RMP (10 and 2.5 µm). [08]

Module 2: Determination of SOx, NOx and CO in ambient air, Demonstration and determination of parameters of stack monitoring. [08]

Module 3: Wind rose diagram to determine the wind direction and velocity of flow; Indore air pollution monitoring. [12]

Module 4: Demonstration of noise pollution monitoring equipment; Development of noise contour diagram in a locality through noise survey. [12]
Module 5: Visit to Industries. [08]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="6">Text Books:
1. Handbook of methods in environmental studies (Volume No. 2).Author: S. K. Maiti. Publisher: Oxford Book Company, 2011; ISBN-13: 9789350300053, ISBN-10: 9350300052.
Reference Books:
1. Air analysis- a practical treatise on the examination of air. Author: James Alfred Wanklyn. Publisher: Nabu Press (September 6, 2011); ISBN-13: 978-1179653167, ISBN-10: 1179653165.</td></tr>
</table>

	Program Outcomes			
	PO1	**PO2**	**PO3**	**PO4**
CO1	**1**	**1**	**3**	**2**
CO2	**3**	**3**	**2**	**3**
CO3	**2**	**1**	**2**	**2**

<table>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ES2053</td><td>Remote Sensing & GIS Practical</td><td>Program Core (PCR)</td><td>0</td><td>0</td><td>4</td><td>4</td><td>2</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Interpret Non Photographic Imagery, Digital Image Analysis, Image Exploration, Verification; Remote Sensing and GIS software: TNT Mips.
• CO2: Know the composition, physical properties of rocks and their effect on environment studies.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module 1: Analysis of satellite imagery with reference to landuse and landcover analysis. [10]
Module 2: Elements of digital image processing. [10]
Module 3: Preparation of thematic maps including overlaying using GIS. [10]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Remote Sensing and GIS - Anji Reddy M., The Book Syndicate, Hyderabad, 2000.ISBN: 978-81-7800-135-7, 81-7800-135-7
Reference Books:
2. Principles of Geographical Information Systems - P A Burrough and R. A. McDonnell, OUP, Oxford, 1998.ISBN-10: 0198233655,ISBN-13: 978-0198233657
3. Geographic Information System- Kang Tsung Chang, Tata Mc Graw Hill, Publication Edition, 2002. ISBN- 0071267581 9780071267588
4. Environmental geology-McGraw Hill Education (India) Private Limited; Second edition,4 July 2013.ISBN-10: 1259058476,ISBN-13: 978-1259058479</td></tr>
</table>

	Program Outcomes			
	PO1	**PO2**	**PO3**	**PO4**
CO1	**3**	**2**	**3**	**2**
CO2	**2**	**1**	**3**	**2**

<table>
<tr><td colspan="7">Department of Earth and Environmental Studies</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ES3051/ ES4051</td><td>DISSERTION – I/ DISSERTION - II / INDUSTRIAL PROJECT</td><td>PCR</td><td>0</td><td>0</td><td>24</td><td>24</td><td>12</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">• CO1: Design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health care, safety and sustainability.
• CO2: Identify, formulate, and solve environmental problems.
• CO3: Develop an understanding of professional and ethical responsibility.
• CO4: Submit a dissertation synopsis comprising of the application and feasibility of the dissertation.</td></tr>
<tr><td>Topics Covered</td><td colspan="6">Dissertation is the report of summarized M.Tech project work. Students are expected to design and develop a complete system or make an investigative analysis of a technical problem in the relevant area. The student has to fix his topic, complete preliminary studies like literature survey, field measurements in the third semester. The progress of project work also included in the dissertation in case of third semester. In fourth semester students need to submit the complete report of the research work.</td></tr>
</table>

	Program Outcomes			
	PO1	**PO2**	**PO3**	**PO4**
CO1	**3**	**3**	**3**	**3**
CO2	**3**	**3**	**3**	**3**
CO3	**3**	**3**	**3**	**3**

<table>
<tr><td colspan="7">Department of Earth and Environmental Studies</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ES3052/ ES4052</td><td>SEMINAR - NON-PROJECT/ PROJECT SEMINAR</td><td>PCR</td><td>0</td><td>0</td><td>4</td><td>4</td><td>2</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">• CO1: Submit a project synopsis comprising of the application and feasibility of the project.
• CO2: Design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health care, safety and sustainability.
• CO3: Demonstrate, presented and communicate effectively.</td></tr>
<tr><td>Topics Covered</td><td colspan="6">Project work for M. Tech thesis is of duration of four semesters and is expected to be completed in the fourth semester. Each student is expected to design and develop a complete system or make an investigative analysis of a technical problem in the relevant area. Along with dissertation report student have to present the relevant thesis work before the evaluating committee in both third and fourth semesters. In third Semester students are expected to do field excursion, conducting of experiments and numerical modelling of obtained data and in fourth semester students supposed to present the complete thesis work.</td></tr>
</table>

	Program Outcomes			
	PO1	**PO2**	**PO3**	**PO4**
CO1	**1**	**3**	**3**	**3**
CO2	**1**	**3**	**3**	**3**
CO3	**1**	**3**	**3**	**3**

ELECTIVES COURSES

<table>
<tr><td colspan="8">Department of Earth and Environmental Studies</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ES9011</td><td>Mining and the Environment</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Understand the importance of mining disasters, mine safety.
• CO2: Demonstrate the Mine Closure: principles, planning, financial provisions
• CO3: Understand the fundamental, scientific basis developing closure plans, progressive and final mine closure.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">MODULE 1: Overview: History of environmental problems in mines and present environmental scenario; Environmental Parameters and Standards: Baseline data, Impact of mining activities on environmental parameters, Mitigating measures, monitoring and control. National and international standards and regulations. [7]
MODULE 2: Environmental Parameters: Water quality – physical, chemical, biological, criteria and standards, Classification and chemistry of major air pollutants. Soil chemistry – nature and importance of soil, soil properties, soil amendments. [5]
MODULE 3: Waste Management : Chemical aspects of environmental pollution by mine wastes and their impact, Production and characterization of solid wastes in different types of mines, Generation and characterization of mine effluents and leachate, Management of different types of mine wastes, [8]
MODULE 4: Ventilation Planning : Central and boundary ventilation, Ventilation schemes for various methods of working, Estimation of the operating pressure and air quantity requirements of mine, Preparation of ventilation plans for underground mines, Control of heat and humidity through air quantity regulation and refrigeration, Control of dust, fumes and other pollutants [8]
MODULE 5: Environmental Hazards In Mines: Mine Fires, Explosions, Inundation, Mine Occupational Diseases – Causes, Detection, monitoring and control. Disaster Management - Emergency organization, Developments in rescue, reviving and resuscitating apparatus, Cooling and fire resistant clothing, Location and rescue of trapped miners, Investigation of disaster. Mine rescue rules; Mine Closure: Principles, planning, financial provisions, implementation, standards for closure criteria, systems approach for mine closure and development of closure plan. [12]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books: Environmental Impact of Mining Down CG and Stocks J. Applied Science Publishers, London, 1978. Publisher: Elsevier Science & Technology
Reference Books: 1. Environmental Impacts of Mining Monitoring, Restoration, and Control, Mritunjoy Sengupta, Publisher: CRC Press (26 March 1993)
2. Best Practice Environmental Management in Mining: Training Kit, Author: Environment Australia Staff, Edition: illustrated, Publisher: Australian Government - Department of the Environment and Heritage, 2002</td></tr>
</table>

	Program Outcomes			
	PO1	**PO2**	**PO3**	**PO4**
CO1				
CO2				
CO3				

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ES9012</td><td>Environmental Geology</td><td>Electives (PEL)</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Understand the importance of geologic cycles, earth and groundwater resources.
• CO2: Demonstrate the effects of natural hazards and their mitigation.
• CO3: Understand the principles of management of energy resources.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module 1: Relevance of Environmental geology; Earth materials and processes – Geologic cycles, Earth Resources: types of rocks, origin and properties, role of natural agencies in earth processes, groundwater resources. [12]
Module 2: Groundwater and its occurrence, hydrological transformations, groundwater movement and groundwater quality. [13]
Module 3: Geological Hazards – Earthquakes, Volcanism, Landslide, Flood, Coastal Hazards. [09]
Module 4: Exploitation of Resources and its impact; Energy and Environment – Coal, Oil and Gas. [06]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. A Textbook of Geology. P. K. Mukerjee. Publisher: World Press; (2006); ISBN-10: 8187567546, ISBN-13:9788187567547.
Hydrology: Principles, Analysis and Design. H. M. Raghunath; Publisher: New Age International; 2nd Edition (2006); ISBN-10: 8122418252, ISBN-13: 9788122418255.
Reference Books:
1. Groundwater Hydrology. David Keith Todd, Larry W. Mays; Publisher: Wiley India; 3rd edition (August 6, 2004); ISBN-10: 8126530030, ISBN-13: 9788126530038.</td></tr>
</table>

	Program Outcomes			
	PO1	**PO2**	**PO3**	**PO4**
CO1				
CO2				
CO3				

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ES9013</td><td>Remote Sensing and GIS</td><td>Electives (PEL)</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Get a brief idea about the remote sensing network and its functioning.
• CO2: Understand the working concept of GIS applications.
• CO3: Get a brief idea about the role of GIS software in identifying large scale environmental problems.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module 1: Fundamental concepts of Remote Sensing, Physics of Remote Sensing, Effects of atmosphere, Electromagnetic spectrum, Atmospheric window, Spectral Reflectance of Earth surface features; Characteristics of Space platforms, sensors, scanning and orbiting mechanisms, Different resolutions, IRS and other remote sensing satellites. [08]
Module 2: Fundamentals of satellite image interpretation; Principles : data encoding and decoding, digital image formats – band sequential and band interleaved; Image rectification and restoration ; Techniques of image interpretation, Multi-spectral data analysis. [06]
Module 3: Overviews of image processing methods for feature extraction, spatial feature manipulation, contrast enhancement, spatial filtering, supervised classification and unsupervised classification; Digital elevation model. [06]
Module 4: GIS – definition, components of GIS, maps, spatial & non-spatial data; Spatial entities – Raster and Vector spatial data structures, Database management system. [06]
Module 5: Data input and editing; Data analyzing operation in GIS; GIS Modelling and Decision Support System, Fundamental concepts of GPS. [06]
Module 6: Environmental application of GIS & RS techniques:
(a) Geosciences & Disaster management : Geomorphology, landform analysis; Natural & manmade disasters, types, zoning & preparedness, integrated approach for landslide hazard zonation mapping.
(b) Water resources: Principles of remote sensing in water resources assessment, Hydrological modelling. [08]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Remote Sensing & GIS, Basudeb Bhatta, 2nd Edition, August 2011, Publisher: Oxford Publications, ISBN-10: 0198072392, ISBN-13: 978-0198072392
Reference Books:
1. Principles of Geographical information Systems, Peter A Burrough and Rachael A Mcdonnel, December 2006, Publisher: Oxford University Press,
2. Essential Image Processing and GIS for Remote Sensing, Jian Guo Liu and Philippa Mason, July 2009, Publisher: Wiley-Blackwell
3. Introduction to Geographic information System, K T Chang, 2007, Publisher: Tata McGraw-Hill Education</td></tr>
</table>

	Program Outcomes			
	PO1	**PO2**	**PO3**	**PO4**
CO1				
CO2				

CO3				

Department of Earth and Environmental Studies							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ES9014	Green Chemistry and Clean Technologies	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					

Course Outcomes	• CO1: Understand the importance and benefits of green chemistry. • CO2: Demonstrate the design for safer, energy efficient technology and process optimization for cleaner industrial processes. • CO3: Understand the fundamentals of pollution prevention. • CO4: Study the industrial application of the techniques.
Topics Covered	**MODULE 1:** Definition and strategy of green chemistry, Why Green Chemistry? Prevention, Atom Economy, Less Hazardous Chemical Syntheses, Designing Safer Chemicals, Safer Solvents and Auxiliaries, Design for Energy Efficiency. **[6]** **MODULE 2:** Use of Renewable, Feed stocks, Reduce Derivatives, Catalysis, Design for Degradation, Real-time analysis for Pollution Prevention, Inherently Safer Chemistry for Accident Prevention, Laboratory pollution prevention . **[8]** **MODULE 3:** Applications and benefits of green chemistry: Production of new chemicals, materials, and products. Examples of successful green technologies; Alternative synthetic routes, new separation processes, new methods for delivery or product application (Alternative solvents, Energy vs. material activity). Importance of pollution and wastefulness in modern cultures by reflecting on the green chemistry. **[12]** **MODULE 4:** Process optimization for cleaner industrial processes; Flow sheet analysis; Energy and resource (material and water) audits for efficient usage and conservation, concept of industrial ecology and symbiosis of eco-industrial parks. [8] **MODULE 5:** Case studies on industrial applications of cleaner technologies in chemical, metallurgical, pulp & paper, textile and other industries. **[6]**
Text Books, and/or reference material	**Text Books: 1.** Green Chemistry: Theory and Practice. Paul Anastas, John Warner. Publisher: OUP USA; Reprint edition (23 March 2000); 2. Green Chemistry and Engineering. Mukesh Doble, Ken Rollins, Anil Kumar. Publisher: Academic Press (27 July 2010); **Reference Books:** 1. Real-world Cases in Green Chemistry. Michael C. Cann, Marc E. Connelly. Publisher: American Chemical Society (2000); ISBN-10: 0841237336, ISBN-13: 9780841237339. 3. Green Chemistry: An Introductory Text. Mike Lancaster, Janet Scott, Karen Wilson. Publisher: Royal Society of Chemistry; New edition (1 May 2010);

	Program Outcomes			
	PO1	**PO2**	**PO3**	**PO4**
CO1				

CO2				
CO3				

Department of Earth and Environmental Studies							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ES9015	Hydrogeology and Watershed Management	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					

Course Outcomes	• CO1: Understand the importance of Hydrology and Watershed Management with the focal theme on Ecosystem Resilience - Rural and Urban Water Requirements. • CO2: Understand the fundamental aspect on the management of forest, woodland, rangeland, agricultural urban and mixed land use watersheds. • CO3: Understand the scientific basis of specialized course work in the management of ground and surface water resources, ecology, watershed, quantity and quality of water. • CO4: Practical ways to acquire data, update methods and models, and apply the latest technologies to issues of land and water use and climate variability and change
Topics Covered	**MODULE 1:** Groundwater and the hydrologic cycle; Water bearing properties of rocks ; Zone of aeration and saturation ; Hydrogeologic formations. **[7]** **MODULE 2:** Groundwater flow – Properties of water in relation to flow, Darcy's law, Flow through aquifers, Storage equations. **[8]** **MODULE 3:** Quality of groundwater; Groundwater provinces in India; Saline water intrusion; Subsurface contaminant transport; Groundwater recharge (including Rainwater Harvesting technique), discharge and balance. **[10]** **MODULE 4:** Meteorology ; Watershed characteristics – Drainage area, Linear measurements, Basin shape, Watershed relief, Drainage pattern, Landcover and landuse ; Stormwater management ; Channel and Reservoir Routing. **[6]** **MODULE 5:** Dams and Barrage ; Various methods of catchment routing ; Assessment of routing techniques ; Soil surveys and land capability classifications ; Erosion and Sedimentation ; Measures for erosion control ; Watershed catchment modeling ; Hydrologic design criteria. **[9]**
Text Books, and/or reference material	**Text Books:** Hydrology and the Management of Watersheds, Kenneth N. Brooks, Peter F. Ffolliott, Joseph A. Magner. 4th Edition, Publisher: Wiley, 2003 **Reference Books:** Hydrological Modelling and the Water Cycle: Coupling the Atmospheric and Hydrological Models (Water Science and Technology Library) by SoroushSorooshian, Kuo-lin Hsu, Erika Coppola, Barbara Tomassetti, Marco Verdecchia, Guido Visconti, Publisher: Springer Science & Business Media, 2008,

	Program Outcomes			
	PO1	**PO2**	**PO3**	**PO4**
CO1				
CO2				

CO3				

Department of Earth and Environmental Studies							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ES9016	Natural Hazards and Disaster Management	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Understand the importance of Natural & Anthropogenic Disasters: Cyclone, flood, drought, land slide, land subsidence, fire, earthquake and others. • CO2: Demonstrate the post disaster recovery & rehabilitation processes. • CO3: Understand the Techniques of monitoring and design against the disasters.						
Topics Covered	**MODULE 1:** Concepts of disaster; Introduction to Natural & Anthropogenic Disasters: Cyclone, flood, drought, land slide, land subsidence, fire, earthquake and others; Issues and concern for various causes of disasters, Psychological and Social Dimensions in Disasters, Trauma and Stress. **[8]** **MODULE 2:** Natural Disasters and Mitigation Efforts, Flood Control, Drought Management, Cyclones, Avalanches, Forest Fires, Oil Fires, Accidents in Coal Mines, Emergency Management, Land Use Planning, Inter-Linking of Rivers ; **[9]** **MODULE 3:** Techniques of monitoring and design against the disasters: Disaster mapping, assessment, pre-disaster risk & vulnerability reduction; **[7]** **MODULE 4:** Recent Trends in Disaster Information Provider, Electronic Warning Systems, Geo Informatics in Disaster Studies, Remote Sensing & GIS Technology **[8]** **MODULE 5:** Post disaster recovery & rehabilitation, Disaster related infrastructure development; Applications in Disaster Management: Statistical Seismology, Quick Reconstruction Technologies, Role of Media in Disasters, Management of Epidemics, Forecasting/ Management of Casualties. **[8]**						
Text Books, and/or reference material	**Text Books:** 1 . Standard Handbook of Hazardous Waste Treatment and Disposal Harry Freeman, Publisher: McGraw-Hill, 1998, Edition: 2, illustrated **Reference Books:** 1. Hazardous Waste Management, 2nd Edition, Michael D. LaGrega, Phillip L. Buckingham, Jeffrey C. Evans, Publisher: Waveland Press, 2010 2. Hazardous Waste Management Engineering Martin EJ & Johnson JH, Van Nostrand-Reinhold, NY, 1987, DOI: 10.1002/ep.670060318, Volume 6, Issue 3 August 1987.						

	Program Outcomes			
	PO1	**PO2**	**PO3**	**PO4**
CO1				
CO2				

CO3				

Department of Earth and Environmental Studies							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ES9017	Environmental management	Electives (PEL)	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					

Course Outcomes	• CO1: Understand the National and International Environmental Policies, Environmental Legislations-Acts, Rules, Regulations and Notifications. Environmental standards, Criteria for standard setting. • CO2: Asses various methods, their applicability, impacts on physical resources, human use values and quality of life value. • CO3: Aspect-Impact Analysis, Continual Improvement, Environmental Performance, Environmental Policy, Vision and Mission Objective and Target Environmental Management Planning.
Topics Covered	**Topic 1:** Introduction to Environmental Management (EM), Participants in EM, Environment and Sustainable Development - carrying capacity, relation among quality of life, carrying capacity and resource utilization, Environmental Audit – methods, procedure, reporting. **[12]** **Topic 2:** Environmental Impact Assessment – Definition, Objectives, Types - Rapid and Comprehensive EIA, EIS, Detailed procedure for conducting EIA, Limitations of EIA. **[8]** **Topic 3:** Prevention of Significant Deterioration (PSD) Programme, Frame work of Impact assessment, Scope and contents of EIA, Methodologies and techniques of EIA, Attributes and Standards, Public participation in EIA. **[10]** **Topic 4:** Environmental Management Technique: Environmental Monitoring, Environmental Modelling, Sensitivity Analysis; Environmental Design. Environmental Standards and Laws: International pollution control law, Legal pollution control in India- special acts- 1) The water (prevention and control of pollution) Act, 1974; 2) The air (prevention and control of pollution) Act, 1981; 3) The environment protection Act, 1986. **[10]**
Text Books, and/or reference material	**Text Books:** • Environmental Management, Vijay Kulkarni, T. V. Ramachandra, Publisher : The Energy and Resources Institute, TERI (1 December 2009), • Environmental Impact Assessment. Author: Larry Canter; Publisher: McGraw-Hill Science/Engineering/Math; 2nd edition (September 1, 1995); **Reference Books:** 2. Environmental Impact Assessment: Theory and Practice. Author: Peter Wathern; Publisher: Rout ledge (14 June 1990); 3. An Introduction to Environmental Audit. Author: R.D. Tripathi; Publisher: Alfa Publications (January 1, 2009); 4. Renewable Energy: Environment and Development. Author: MaheshwarDayal; Publisher: Konark Publication, 1991;

	Program Outcomes			
	PO1	**PO2**	**PO3**	**PO4**
CO1	**2**	**1**	**1**	

CO2	**3**	**2**		
CO3		**2**	**1**	**3**

Department of Earth and Environmental Studies							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ES9018	Noise Control Engineering	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					

Course Outcomes	• CO1: Understand the theory of noise generation and monitoring. • CO2: Understand the fundamental, scientific basis governing the design and performance of the noise prevention equipments. • CO3: Manage noise pollution in a surrounding by improvising strategic control.
Topics Covered	**MODULE 1:** Fundamentals of sound and hearing; Nature of noise, effects, sources; Noise rating and noise measurement. **[8]** **MODULE 2:** Noise control in buildings (airborne and structure born sound insulation, reduction of noise from building services). **[8]** **MODULE 3:** Noise control in the urban environment (outdoor sound propagation, noise reduction measures). **[8]** **MODULE 4:** Noise control in industry (indoor sound propagation, noise control of indoor noise sources). **[8]** **MODULE 5:** Legal aspects of noise pollution; Assessment of impacts of noise environment. **[8]**
Text Books, and/or reference material	**Text Books:** Engineering Noise Control: Theory & Practice, David A Bies and Colin A Hansen, 4th Edition, June 2009, Publisher: CRC Press, ISBN-10: 0415487072, ISBN-13: 978-0415487072. **Reference Books:** 1. Environmental Engineering, A P Sincero& G A Sincero, 2008, Publisher: PHI Learning, ISBN-10: 8120314740, ISBN-13: 978-8120314740. 2. Mechanical Vibrations and Industrial Noise Control, L G Lasithan, February 2014, Publisher: PHI Learning India, ISBN-10: 8120347993, ISBN-13: 978-8120347993. 3. Industrial Noise Control and Acoustics, Randall F Barron, November 2002, Publisher: CRC Press, ISBN-10: 0824707019, ISBN-13: 978-0824707019

	Program Outcomes			
	PO1	**PO2**	**PO3**	**PO4**
CO1				
CO2				
CO3				

<table>
<tr><td colspan="8">Department of Earth and Environmental Studies</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ES9019</td><td>Mathematical Modelling in Environmental Engineering</td><td>Electives (PEL)</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Understand the key numerical analysis methods and their applications to solve common engineering problems.
• CO2: Understand the significance, calculation and interpretation of numerical errors and convergence criteria associated with numerical analysis.
• CO3: Implement of numerical methods to solve real life problems.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module 1: Environmental modelling: Introduction to mathematical modelling, problems and prospects of such modelling in different fields of environment. Case Study. Approximations and errors: accuracy and precision, round-off errors, truncation errors, Taylor’s series, total numerical error. [9]
Module 2: Roots of equations: graphical method, bisection method, false position method, fixed point iteration method, Newton-Raphson method, Secant method, multiple roots, system of nonlinear equations, roots of polynomials, Muller’s method, Bairstow’s method. [7]
Module 3: Solution of linear algebraic equations: Gauss elimination, pivoting, scaling, Gauss – Jordan, Gauss – Siedel, LU decomposition, Tridiagonal systems, Cholesky decomposition. Curve fitting: Least squares regression, linear regression, polynomial regression, multiple linear regression, nonlinear regression. [9]
Module 4: Ordinary differential equation: Picard’s Method, Taylor’s series method, Euler’s method, Heun’s method, midpoint method, Runge – Kutta methods, Multi step methods- Predictor-corrector method- Euler’s Method, Milne’s method, Adam-Bashforth’s Moulton’s Method. Partial differential equations: Liebmann’s method, Jacobi’s method, Gauss- Seidal method; Application of Finite difference and Finite element method in Engineering. [17]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Numerical Methods, S. Dey and S. Gupta, Publisher: McGraw Hill Education (India) Private Limited, 2014. ISBN(13): 9871259062582; ISBN(10): 1259062589.
2. Numerical methods for engineers, 5th Edition, Steven C. Chapra; Publisher: Tata Mcgraw hill edition 2006. ISBN-13:9780070634169, 10:0070634165.
Reference Books:
1. Environmental Hydraulics: Numerical Methods Volume 3 Edition, Jean-michel (editor) Tanguy, Publisher Wiley-iste,
2. Introductory Methods of Numerical Analysis 5th Edition, S.S Sastry, Publisher: PHI Learning, ISBN-108120345924, ISBN-139788120345928.
3. Numerical Methods For Scientists And Engineers 2nd Edition, H. M. Antia, Publisher: Birkhauser, ISBN-10-3764367156, ISBN-13-9783764367152.</td></tr>
</table>

	Program Outcomes			
	PO1	**PO2**	**PO3**	**PO4**
CO1			**3**	
CO2	**2**		**2**	

CO3		**1**	**2**	**3**

Department of Earth and Environmental Studies							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ES9020	Environmental Radiochemistry	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Understand the science of radioactivity and radioactive elements. • CO2: Understand the fundamental aspect on the thermodynamics of radioisotope. • CO3: Determine the effect of radioactive elements on living species on the earth. • CO4: Practical ways to acquire data, update methods and models, and apply the latest technologies to issues of natural and anthropogenic generated radiation effect						
Topics Covered	**MODULE 1:** Basic of nuclear chemistry; Mass-energy relation of atomic nuclei, Concept of nuclear angular momentum, magnetic dipole moment, nuclear binding energy and stability of atomic nucleus. **[6]** **MODULE 2:** Liquid drop model, binding energy equation and its application.Radioactive decay and equilibrium, types of reactions, nuclear reactor and its design, chemical effects of nuclear transformations, fission and fusion, fission products and fission yields.Calculation **[11]** **MODULE 3:** Radioactive techniques: tracer technique, neutron activation analysis, counting techniques such as G.M. ionization and proportional counter. **[11]** **MODULE 4:** Biological effects of radiations, manmade and natural radiation, application of nuclear radiation for medicine, agriculture and environmental sample analysis. **[12]**						
Text Books, and/or reference material	**Text Books:** 1. Essentials of Nuclear Chemistry by HariJeevanArnikar, Issue 1653 of Journal of chemical education collection, Publisher: New Age International, 1995, 2. Nuclear and Radiochemistry: Fundamentals and Applications, Karl Heinrich Lieser, Publisher: John Wiley & Sons, 2008, ISBN: 3527612572, 9783527612574. **Reference Books:** 1. Radiochemistry and Nuclear Chemistry 1by Gregory Choppin (Author), Jan-OlovLiljenzin (Author), Jan Rydberg (Author), Christian Ekberg Laboratory of Nuclear Chemistry, Institute of Chemistry, EötvösLoránd University, Budapest, HungaryISBN-13: 978-0124058972, ISBN-10: 0124058973, Publisher: Academic Press; 4 edition (October 8, 2013). 2. Handbook of Environmental Isotope Geochemistry, Mark Baskaran, Publisher: Springer Science & Business Media, 2011, ISBN: 3642106374, 9783642106378.						

	Program Outcomes			
	PO1	**PO2**	**PO3**	**PO4**
CO1				
CO2				

CO3				

Department of Earth and Environmental Studies							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ES9021	Environmental Biotechnology	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					

Course Outcomes	CO1: Understand the bioremediation process fundamentals – principles and various biochemical, enzymatic and genetic mechanisms of bioremediation processes and their regulation. CO2: Understand different bioremediation approaches and strategies under various conditions CO3: Understand the different techniques used in treatment of hazardous wastes, especially radioactive wastes and how to analyze the risk involved. CO4: Understand the techniques used in various industries for treatment of their wastes and problems thereof.
Topics Covered	**Module I:** Introduction, Types of pollutants, sources of pollutants, magnitude of contamination problem, merits and limitations of bioremediation, bioremediation of organic and inorganic pollutants. **[5]** Microbial interactions with heavy metals/radionuclides – bioaccumulation, biosorption, biotransformation, bioprecipitation, applications of metal-microbe interactions. **Module II:** Biodegradation principles – microbial processes, biotransformation, mineralization, detoxification, activation, cometabolism and growth associated degradation. Requirements for biodegradation, cooperation between different microbial species for enhanced biodegradation, Implications of recalcitrance, acclimation, biotransformation mechanisms, enzymes, reactions, Biodegradation pathways and metabolites, effect of contaminant structure on biodegradability. **[10]** **Module III:** Bioremediation strategies – natural attenuation and accelerated bioremediation, aerobic, anaerobic, ex-situ, in-situ, biostimulation, bioaugmentation Phytoremediation – phytoextraction, rhizofiltration, phytodegradation, phytovolatilization, rhizoremediation, phytostabilization. **[5]** **Module IV:** Treatment of industrial wastes like Dairy, sugar & distillery, pharmaceutical, textile etc.. Biodegradation of pesticides, dyes, polymers, polyaromatic hydrocarbons etc. **[10]** **Module V:** Estimation of Biokinetic parameters. Aerobic and anaerobic sludge digestion. Design of biomethanation process. Biotechnological application of hazardous waste management – nuclear industry waste. Hospital waste management. Vermiculture. Phycoremediation. Energy from waste. **[11]**
Text Books, and/or reference material	**Text Books** 1. Biology of wastewater treatment by N F Gray; Imperial College Press. 2. Biotreatment of industrial effluents, Mukesh Doble, Elsevier, 3. Bioremediation and Natural attenuation – Process fundamentals and mathematical models, P.J.J.Alvarez and W.A.Illman, Wiley-Interscience 0-471-65043--9 4. Introduction to Wastewater Treatment Processes, R S Ramalho, Academic Press,

	Reference Books 1. Wastewater Treatment for Pollution Control & Reuse, Soli J Arceivala, Shyam R Asolekar, McGraw Hill, ISBN 9780070620995

	PO1	**PO2**	**PO3**	**PO4**
CO1	**2**	**2**	**2**	**2**
CO2	**2**	**2**	**2**	**2**
CO3	**2**	**2**	**2**	**2**
CO4	**2**	**2**	**2**	**2**

Department of Earth and Environmental Studies							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ES9022	Mathematical Modelling in Environmental Engineering	Electives (PEL)	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Analyse physicochemical mechanism of rock-water interaction. • CO2: Describe and explain the physical mechanisms that lead to the transport and attenuation of solutes through porous and fractured media. • CO3: Determine the significance of various contamination sources leading to groundwater contamination. • CO4: Analyse the potential impact of different contamination scenarios. • CO5: Develop and evaluate some possible remediation alternatives and understand their limitations. • CO6: Perform a detailed analysis of a particular contamination problem.						
Topics Covered	**Module 1: Groundwater quality:** Water quality standards, collection of groundwater samples, Field Analysis and sample conservation, Accuracy of chemical Analysis; Use of mass balance to assess water quality, water quality in vadose zone, Generalized control on groundwater quality, Generalized presentation of water quality data, Groundwater monitoring techniques. [5] **Module 2: Chemical principles and groundwater:** Chemical equilibrium; association and dissociation of dissolved species; effects of concentration gradients; Mineral dissolution and solubility; oxidation and reduction process; Ion exchange and adsorption. [4] **Module 3: Chemical Evaluation of Natural Groundwater:** Hydrochemical sequence and Facies; Groundwater in carbonate terrain; Groundwater in Crystalline rocks; groundwater in sedimentary rocks. [6] **Module 4: Groundwater contamination:** Septic tanks and cesspools; Landfills; Chemical spill and leaking underground tank; agricultural activities; Industrial effluent outfall, Mining, Saline-water intrusion and other sources. [4] **Module 5: Concepts and principles related to the movement of solutes in groundwater systems:** Continuity equation and Ficks' law, mass transfer (adsorption, desorption, absorption, decay, dissolution and volatilization); mass transport (advective, dispersive and diffusive flux), Solute transport in double-porosity media. [4] **Module 6: Transformation, Retardation, and Attenuation of Solutes:** Linear and nonlinear (Frendlich and Langmuir) isotherms, equilibrium and kinetic adsorption,						

	Determination of adsorption coefficients, Determination of flow velocity and dispersivity coefficients, Hydrodynamics dispersion, longitudinal and lateral dispersivity. [6] **Module 7: Groundwater Transport Modelling:** Analytical solution of classical advective-dispersion equation, Finite difference and finite element approach, Discussion of boundary conditions, Steady state and transient model, Modelling framework for solute transport in saturated and unsaturated media, Introduction to Visual MODFLOW in groundwater flow and contaminant transport modelling. [6] **Module 8: Remediation Techniques:** Pump-and treat, Permeable reactive barriers and their design, Soil vapour extraction, Air Stripping, bioremediation and phytoremediation processes, wetland processes. [5]
Text Books, and/or reference material	4. Geotechnical practice for waste disposal by D.E. Daniel 5. Geoenvironmental Engineering: Site remediation, waste containment and emerging waste management technologies by H.D. Sharma & K.R. Reddy 6. Hydrology by H.M. Raghunath 7. Applied Hydrogeology by C.W. Fetter

	Program Outcomes			
	PO1	**PO2**	**PO3**	**PO4**
CO1				
CO2				
CO3				

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