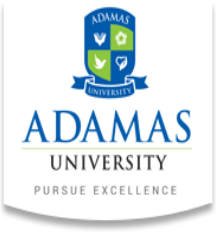
ADAMAS UNIVERSITY

SCHOOL OF BASIC AND APPLIED SCIENCES

DEPARTMENT OF CHEMISTRY

PROGRAMME COURSE STRUCTURE & PROPOSED SYLLABUS FOR M.Sc. IN ENVIRONMENTAL SCIENCE

COURSE STRUCTURE AND SYLLABUS OF TWO-YEARS M.Sc. DEGREE COURSE 2019-2022



DEPARTMENT OF CHEMISTRY
ADAMAS UNIVERSITY

Adamas University

Department of Chemistry

School of Basic and Applied Sciences

Postgraduate Course Structure

Programme Name: **M.Sc. in Environmental Science**

Programme Duration: **4 Semesters or 2 years**

This postgraduate programme *viz.* **M.Sc. in Environmental Science** is a regular fulltime programme spanned for four semesters. Through this programme, it is intended to provide a comprehensive view of some of the major fields of interest in Environmental Science and to develop the student's ability in conducting independent research in his chosen area of specialization. Graduates are prepared for scientific careers in academics or research institutions, and in industry, particularly in research and development.

Programme Eligibility: Passed B.Sc (Hons.) or B.Sc. Major or B.Sc.(General) with Chemistry as a subject read for 3 years. Minimum grade point or percentage in undergraduate course will depend on the policy of the university.

ADAMAS UNIVERSITY, KOLKATA
SCHOOL OF BASIC AND APPLIED SCIENCES
DEPARTMENT OF CHEMISTRY
PROGRAMME: PG IN ENVIRONMENTAL SCIENCE

VISION OF THE UNIVERSITY

To be an internationally recognized university through excellence in inter-disciplinary education, research and innovation, preparing socially responsible well-grounded individuals contributing to nation building.

MISSION STATEMENTS OF THE UNIVERSITY

M.S 01: Improve employability through futuristic curriculum and progressive pedagogy with cutting-edge technology

M.S 02: Foster outcomes based education system for continuous improvement in education, research and all allied activities

M.S 03: Instill the notion of lifelong learning through culture of research and innovation

M.S 04: Collaborate with industries, research centers and professional bodies to stay relevant and up-to-date

M.S 05: Inculcate ethical principles and develop understanding of environmental and social realities

CHANCELLOR / VICE CHANCELLOR

ADAMAS UNIVERSITY, KOLKATA
SCHOOL OF BASIC AND APPLIED SCIENCES
DEPARTMENT OF CHEMISTRY
PROGRAMME: PG IN ENVIRONMENTAL SCIENCE

VISION OF THE SCHOOL

To be recognised globally as a provider of education in Basic and Applied Sciences, fundamental and interdisciplinary research.

MISSION STATEMENTS OF THE SCHOOL

M.S 01: Develop solutions for the challenges in sciences through value-based science education.

M.S 02: Conduct research leading to innovation in sciences.

M.S 03: Nurture students into scientifically competent professionals in the usage of modern tools.

M.S 04: Foster in students, a spirit of inquiry and collaboration to make them ready for careers in teaching, research and corporate world.

DEAN / SCHOOL CONCERNED

ADAMAS UNIVERSITY, KOLKATA
SCHOOL OF BASIC AND APPLIED SCIENCES
DEPARTMENT OF CHEMISTRY
PROGRAMME: PG IN ENVIRONMENTAL SCIENCE

VISION OF THE DEPARTMENT

The Vision of the Department of Chemistry is to generate and disseminate Chemistry education among its pupils such that at individual level, a Chemistry graduate should be inspired with a sense of curiosity and wonder about the fundamental nature of the world around the student; be empowered with the ability to make decisions about their own lives and critically evaluate scientific and technological developments that impact society and lastly be equipped them with the knowledge and skills to pursue further study and rewarding careers in the chemical sciences and a wide range of related fields.

MISSION STATEMENTS OF THE DEPARTMENT

M.S 01: To represent a clear framework or narrative that gives a coherent 'big picture' of chemistry as a subject, explains why it matters, and shows how different areas of content are connected.

M.S 02: To prepare competitive and professional graduates within an innovative and intellectually stimulating environment, support other academic programs at Adamas University by offering quality chemistry learning experiences, conduct basic and applied research of national and international impact.

M.S 03: To advance a knowledge platform that supports an invent-and-design culture in graduate and undergraduate chemistry education, and that empowers students to address and solve challenges of global significance.

M.S 04: To reach out to our future thought leaders—students of all backgrounds from pre-college to doctoral candidates—to share the power of chemistry to create new knowledge directed at the major unmet needs of our time

HEAD OF THE DEPARTMENT **DEAN OF SCHOOL**

ADAMAS UNIVERSITY, KOLKATA
SCHOOL OF BASIC AND APPLIED SCIENCES
DEPARTMENT OF CHEMISTRY

Name of the Programme: Master of Science in Environmental Science

PROGRAMME SPECIFIC OUTCOME (PSO)

PSO 01: Meaningful and socially useful employment: To sensitize students towards environmental issues, and impacts of various anthropogenic activities on global climate and related mitigation strategies, to enable the students for practical application of their knowledge and prepare them for successful and meaningful careers in research and academics, industries, environmental consultancies and NGOs.

PSO 02: Encourage innovation: To encourage innovation that is exposure driven where students can apply their knowledge of the sciences within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource management, and loss of biodiversity.

PSO 03: Professional training: This course will enable the students to get exposed to the real-world situations through nature trails and studies, excursions, industry visits, sophisticated research laboratory visits, rural outreach, socio-economic surveys and most importantly inculcate a scientific temper.

PSO 04: **Scientific communication skills**: To prepare students in such a way so that they can communicate science effectively through written work and oral presentations to a variety of audiences.

PSO 05: **Leadership qualities**: Postgraduate students will attain leadership quality to handle all kind of circumstances in diversities by providing interdisciplinary and multidisciplinary learning environment with team work philosophy.

HEAD OF THE DEPARTMENT **DEAN OF SCHOOL**

ADAMAS UNIVERSITY, KOLKATA
SCHOOL OF BASIC AND APPLIED SCIENCES
DEPARTMENT OF CHEMISTRY

Name of the Programme: Master of Science in Environmental Science

GRADUATE ATTRIBUTE / PROGRAMME OUTCOME (PO)

GA 01 / PO 01: **Critical problem solving:** Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.

GA 02 / PO 02: Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.

GA 03 / PO 03: Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting

GA 04 / PO 04: Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource management, and loss of biodiversity.

GA 05 / PO 05: Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental issues.

GA 06 / PO 06: Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.

GA 07 / PO 07: Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques

GA 08 / PO 08: Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.

GA 09 / PO 09: Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.

HEAD OF THE DEPARTMENT **DEAN OF SCHOOL**

Semester Curriculum for Postgraduate (M.Sc.) Program in Environmental Science

Course Distribution

A. GENERAL THEORY

Discipline/ Name (Theory)	Paper No	Total Credits	L-T-P
1. Energy and Environment	1	3	3-0-0
2. Environmental Chemistry	1	4	4-0-0
3. Atmospheric Science	1	3	3-0-0
4. Ecology and Biodiversity	1	3	3-0-0
5. Mathematics foundation	1	2	2-0-0
6. Natural Resources	1	2	2-0-0
7. Air Pollution and Control Technology	1	4	4-0-0
8. Water Pollution and Control Technology	1	4	4-0-0
9. Environmental Geosciences	1	3	3-0-0
10. Environmental Instrumentation	1	2	2-0-0
11. Statistical applications in Environmental Systems	1	4	4-0-0
12. Solid and Hazardous Waste Management	1	4	4-0-0
13. Environmental Microbiology and Biotechnology	1	4	4-0-0
14. Environmental Impact Assessment and Regulatory Framework	1	3	3-0-0
15. Environmental Health, Biochemistry and Toxicology	1	2	2-0-0
Total	**15**	**47**	

B. GENERAL LAB

Discipline/ Name (Practical)	Paper No	Total Credits	L-T-P
1. Environmental Chemistry	1	4	0-0-8
2. Ecology	1	2	0-0-4
3. Environmental Monitoring Lab	1	4	0-0-8
4. Environmental Instrumentation	1	2	0-0-4
5. Environmental Geosciences	1	4	0-0-8
6. Computational Lab	1	2	0-0-4
7. Environmental Microbiology & Biotechnology	1	2	0-0-4
8. Environmental Health, Biochemistry& Toxicology	1	2	0-0-4
Total	**8**	**22**	

C. ADVANCED ELECTIVE PAPERS

Discipline/ Name	Paper No	Total Credits	L-T-P
1. Advanced Elective I	1	4	4-0-0
2. Advanced Elective I (Lab)	1	2	0-0-4
3. Advanced Elective II	1	2	2-0-0
4. Advanced Elective III	1	2	2-0-0
Total	**4**	**10**	

D. FIELD/PROJECT/DISSERTATION/INDUSTRY INTERACTION/VIVA

Discipline/ Name	Paper No	Total Credits
1. Field visit	1	2
2. Industry Internship	1	2
3. Excursion	1	3

4. Dissertation	1	10
5. Seminar on Contemporary Research	1	2
6. Comprehensive Viva	1	2
Total	**6**	**21**

Distribution of Papers Semester-wise:

Environmental Science PG-I

Semester - I				
Paper Name	**Paper Code**	**No of Papers**	**Credit**	**L-T-P**
1. Energy and Environment	SEN51101	1	3	3-0-0
2. Environmental Chemistry	SEN51103	1	4	4-0-0
3. Atmospheric Science	SEN51105	1	3	3-0-0
4. Ecology and Biodiversity	SEN51107	1	3	3-0-0
5. Mathematics Foundation	SMA51171	1	2	2-0-0
6. Natural Resources and Environment	SEN51109	1	2	2-0-0
7. Environmental Chemistry Lab	SEN51201	1	4	0-0-8
8. Ecology Lab	SEN51203	1	2	0-0-4
9. Field visit	SEN51701	1	2	
Total			**25**	

Environmental Science PG-II

Semester II				
Paper Name	**Paper Code**	**No of Papers**	**Credit**	**L-T-P**
1. Air Pollution and control Technology	SEN51102	1	4	4-0-0
2. Water Pollution and Control Technology	SEN51104	1	4	4-0-0
3. Environmental Geosciences	SEN51106	1	3	3-0-0

4. Environmental Instrumentation (Th)	SEN51108	1	3	3-0-0
5. Environmental monitoring laboratory	SEN51202	1	4	0-0-8
6. Environmental Instrumentation (Lab)	SEN51204	1	2	0-0-4
7. Environmental Geosciences Lab	SEN51206	1	3	0-0-6
8. Industry Internship	SEN51702	1	2	
Total			**25**	

Environmental Science PG-III

Semester III				
Paper Name	**Paper Code**	**No of Papers**	**Credit**	**L-T-P**
1. Statistical application in Environmental Systems	SEN52101	1	4	4-0-0
2. Solid and Hazardous Waste Management	SEN52103	1	4	4-0-0
3. Environmental Microbiology and Biotechnology	SEN52105	1	4	4-0-0
4. Elective I - RS and GIS for Environmental Planning and Management	SEN52107	1	4	4-0-0
OR				
Soil Science	SEN52109	1	4	4-0-0
5. Computational lab	SEN52201	1	2	0-0-4
6. Elective I (Lab) - RS and GIS for Environmental Planning and Management	SEN52203	1	2	0-0-4
OR				
Soil Science Lab	SEN52205	1	2	0-0-4
7. Excursion	SEN52701	1	3	
8. Environmental Microbiology and Biotechnology (Lab)	SEN52207	1	2	0-0-4
Total			**25**	

Semester IV				
Paper Name	**Paper Code**	**No of Papers**	**Credit**	**L-T-P**
1. Environmental Impact Assessment and Regulatory Framework	SEN52102	1	3	3-0-0
2. Elective II- Industrial pollution prevention and clean technologies	SEN52104	1	2	2-0-0
OR				
Design for water and wastewater systems	SEN52106	1	2	2-0-0
3. Elective III - Environmental Economics, Ethics and Policies	SEN52108	1	2	2-0-0
OR				
Occupational health safety and Environmental Management	SEN52110	1	2	2-0-0
4. Environmental Health, Biochemistry and Toxicology	SEN52112	1	2	2-0-0
5. Environmental Health, Biochemistry and Toxicology Lab	SEN52202	1	2	0-0-4
6. Comprehensive viva	SEN52702	1	2	
7. Seminar on contemporary research	SEN52704	1	2	
8. Dissertation	SEN52706	1	10	
Total			**25**	

TOTAL CREDIT: 100

Options for Advanced Elective I Papers (Theory + Practical)	
Sl. No	**Name of the Paper**
1.	GIS for Environmental Planning and Management
2.	Soil Science

Options for Advanced Elective II Papers (Theory)	
Sl. No	**Name of the Paper**
1.	Industrial Pollution prevention and Clean Technologies
2.	Design for Water and Wastewater Systems

Options for Advanced Elective III Papers (Theory)	
Sl. No	**Name of the Paper**
1.	Environmental Economics, Law and Policies
2.	Occupational Health Safety and Environmental Management

****** Total credit of the programme M.Sc. Environmental Science : 25(1st Sem) + 25 (2nd Sem) + 25 (3rd Sem) + 25 (4th Sem) = 100**

[1] N.B.: Students are highly encouraged to enrol their names for the suitable courses offered having minimum credit point**2** by **UGC-MOOCs**. A Vertical of **SWAYAM** courses as one of the skill enhancement courses. The number/grade obtained by the students following the completion of this type of courses will carry equivalent weightage/ credit for the fulfilment of their courses. The name of the courses opted by the students will be reflected in the mark sheet as reported by Head of the Department or Programme In-Charge (empowered by the Dean, SOS) to the examination section of the university.

SEN51101	Energy and Environment	L	T	P	C
Version 1.0	**Contact Hours – 45**	3	0	0	3
Pre-requisites/Exposure	Basic physics, chemistry, biology and mathematics.				
Co-requisites	-				

Course Objectives

1. To understand the multidisciplinary nature of the subject and provide an integrated, quantitative, and interdisciplinary approach to the study of environmental systems.
2. To develop the basic concepts behind the genesis of the environmental ideologies.
3. To understand the relation between energy resources and environment.
4. To be able to understand causes and effects of environmental pollution by over exploitation of natural resources.
5. To have a basic knowledge about sustainable development.

Course Outcomes

On completion of this course, the students will be able to

CO1.	Explain the various factors triggering the evolution of environmental thought.
CO2.	Identify the various environmental variables, their interrelationships in the context of biosphere.
CO3.	Explore the avenues through which increasing energy demands have affected our environment.
CO4.	Compare the advantages and disadvantages of various energy resources.
CO5.	Identify the major routes and approach roads towards sustainability.

Course Description: The science of Environment studies is a multi-disciplinary science because it comprises various branches of studies like chemistry, physics, medical science, life science, agriculture, public health, sanitary engineering etc. It is the science of physical phenomena in the environment. It studies of the sources, reactions, transport, effect, and fate of physical a biological species in the air, water and soil and the effect of from human activity upon these. Life requires energy. Sun is the only source of energy in the solar system, which makes studying the energy budget of the earth even more unavoidable. Thorough knowledge about the energy resources is extremely important. As the resources in this planet is depleting fast, and so is the rate of increase of human population, there is always a fear of our future generations not having access to sufficient resources for their survival. Therefore, until and unless we opt for development, which is sustainable ink its philosophy, we will be doing injustice to our own future generations.

Detailed syllabus

Unit I: Basic concepts of Environmental Science: (15L)

Principle and scope of environmental science; Introduction to the interdisciplinary approach to environmental science; History of environmental thought and environmentalism; Environmental education and awareness; Gaia Concept; Deep Ecology; Evolution and Ecology; Adaptation; Co-evolution; Selection; Basic outline of evolutionary biology and chronology of human civilization and society; Demography; Process of cultural transmission; Man-Environment interaction; Nature vs. Nurture; Ecofeminism; Women and Environment; Green Politics; Environmental movements in India; Environmental Education.

Unit II: Energy resources: (20L)

What is energy; Various forms of energy; Thermodynamics; Energy budget of the earth; Fossil fuels: classification, composition, physico-chemical characteristics and energy content of coal, petroleum and natural gas; Shale oil, Coal bed Methane (CBM); Gas hydrates; Gross-calorific value and net-calorific value; Sun as source of energy: solar radiation and its spectral characteristics, solar collectors, photo-voltaic modules, solar ponds ; Principles of generation of hydro-power; tidal energy; ocean thermal energy conversion (OTEC); wind power; geothermal energy;; Magneto hydrodynamic power; fuel cell and their techno-economic comparison; Nuclear energy - fission and fusion; Nuclear fuels; Nuclear reactor – principles and types; Bioenergy: methods to produce energy from biomass; Environmental implications of energy use; energy use pattern in India and the world, emissions of CO_2 in developed and developing countries; Global energy use pattern; Smart usage of energy; Energy security; Energy audit; Evolution of battery

Unit III: Concept of Sustainability (10L)

Fundamental concepts about Sustainable Development; Human impacts on natural resources; Causes of unsustainability; Concept of Sustainable Agriculture; India's environment action programme: issues, approaches and initiatives towards Sustainability; Sustainable development in practice; Urbanization and Concept of Smart city; Depleting urban resources and allied problems; Carrying capacity analysis; Concept of ecological footprints.

Text books:

1. Roy S.,Environmental Science, Publishing Syndicate, Kolkata
2. Santra, S.C., Environmental Science, New Central Book Agency (P) Ltd., Kolkata
3. Rai G.D, Non-conventional energy sources, Khanna Publishers
4. Dash. M.C., Concepts of Environmental Management, Dreamtech Press (1 January 2019).

Reference Books:

1. Anjaneyulu Y. Introduction to Environmental Science. B.S Publication.
2. Enger E, Smith B. Environmental Science. A Study of Interrelationships. McGraw-Hill Higher Education.
3. Khan B.H. Non-conventional energy resources, McGraw Hill Education India Private Limited; Third edition (1 July 2017).

4. Twidell J and Weir T, Renewable energy resources, Routledge; 3rd edition (26 January 2015).
5. Ahlawat A., Sustainable development goals: Directive principles for sustainable India by 2030. Notion Press; 1st edition (7 October 2019).
6. Ossewarde M.J., Introduction to Sustainable Development, SAGE Publications Pvt. Ltd; First edition (15 April 2018).

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Energy and Environment		**Course Code : SEN51101**
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO 1	Explain the various factors triggering the evolution of environmental thought.	**PO1, PO2, PO3, PO4, PO8, PSO1, PSO3**
CO 2	Identify the various environmental variables, their interrelationships in the context of biosphere.	**PO4, PO5, PO8, PO9, PSO1, PSO2**
CO 3	Explore the avenues through which increasing energy demands have affected our environment.	**PO2, PO4, PO6, PO8, PSO2**
CO 4	Compare the advantages and disadvantages of various energy resources.	**PO3, PO5, PSO2**
CO 5	Identify the major routes and approach roads towards sustainability.	**PO3, PO4, PO9, PSO3**

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	**Internal**	**Attendance**	**Mid Term**	**End Term**
Weightage (%)	**30**	**10**	**20**	**40**

		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource management, and loss of biodiversity.	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental issues.	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO1	PO 2	PO3	PO4	PO 5	PO6	PO 7	PO 8	PO 9	PS O1	PSO 2	PSO 3	PS O 4	PS O 5
SEN51101	**Energy and environment**	3	3	3	3	2	1	3	3	3	2	1	2	3	2

1 = weakly mapped

2 = moderately mapped

3 = strongly mapped

Model Question Paper

Name: **Enrolment No:**	

Course: SEN51101 – Energy and environment

Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**
Semester: Odd 2020-21 **Max. Marks: 40**
Total no. of questions: 12

Instructions:
Attempt all (five) questions from **Section A** (each carrying 2 marks); any **Four Questions** from **Section B** (each carrying 5 marks); any one question from **Section C** (carrying 10 marks)**.**

Section A (Attempt **all the questions)**			
1.	Discuss the concept of Deep Ecology.	**U**	**CO1**
2.	What is the focal theme of the Gaia Concept?	**An**	**CO2**
3.	Is nuclear energy a clean source of energy? Why?	**An**	**CO5**
4.	What do you mean by OTEC?	**R**	**CO4**
5.	How is sustainability related to energy consumption?	**E**	**CO3**
Section B (Attempt any **four questions)**			
6.	Compare between the energy content of coal, petroleum and natural gas	**U**	**CO6**
7.	Discuss the concept of smart city.	**U**	**CO5**
8.	What do you mean by solar ponds?	**R**	**CO4**
9.	What according to you are the lacunae in promotion of environmental education in India?	**C**	**CO3**
10.	Is ‘greenwashing’ a mere marketing gimmick or a tool towards a green economy?	**E**	**CO1**
Section C (Attempt any **one question)**			
11.	Explain the basic principles of power generation from (a) hydro-power and (b) tidal energy. Explain with diagrams. (5+5 = 10)	**R**	**CO5**
12.	What do you mean by sustainable development? Discuss the concept of sustainable agriculture. Explain the role of any one notable environmental movement in India in developing the notion of sustainability amongst the masses. (2+3+5 = 10)	**E**	**CO2**

SEN51103	Environmental Chemistry	L	T	P	C
Version 1.0		4	0	0	4
Pre-requisites/Exposure	Basic physics, chemistry, biology and mathematics.				
Co-requisites	-				

Course Objectives

1. To understand, comprehend and demonstrate the fundamental concepts of chemical principles of fundamental environmental processes in air, water, and soil.
2. To develop the basic chemical concepts required to understand analytical processes involved in different environmental issues pertaining to solid, liquid and gaseous matrix.
3. To understand the underlying principles and chemistry involved in environmental purification, remediation, and waste treatment processes.
4. To be able to understand causes and effects of environmental pollution by different industries, possible mitigation strategies and different aspects of green chemistry and sustainability
5. To have a basic knowledge about the different types of toxic substances & responses and analyse toxicological information.

Course Outcomes

On completion of this course, the students will be able to

CO1.	Identify key environmental compartments and processes in the air, water and soil.
CO2.	Examine presence and fate of chemicals in the environment through use of field instrumentation, computer models, data analysis.
CO3.	Explain the theoretical basis and observational methods for study of contaminants and interactions with the land surface, biota and climate change.
CO4.	Identify the major transport mechanisms of pollutants in the environment.
CO5.	Compare chemical properties for toxicants and xenobiotics of environmental concern.

Course Description: This course aims to provide the essential concepts of basic chemistry which is extremely important to understand all the chemical, physico-chemical and bio-chemical processes occurring around us. This course helps to develop a strong foundation of mathematical formulations of basic chemistry. On completion of this course, students will learn about different environmental phenomena explainable with basic principles of chemistry. Portions involving physical, inorganic and organic chemistry are systematically developed in this course, which culminates in understanding air, water, soil and toxicological chemistry. Classroom activities will be designed to encourage students to play an active role in the applying the knowledge gained to solve problems and explain different observations around us. Most importantly they will attain the driving force through which their vision and perspective will undergo a paradigm change in understanding this multidisciplinary subject.

Detailed syllabus

Unit I: Basic Chemistry **(15L)**

Mole Concept; Stoichiometry; Units of strength and concentration; Volumetric calculations, Atomic structure; electronic configuration; Periodic Table and periodic properties of elements (ionization potential, electron affinity and electronegativity); Chemical bonding; quantitative volumetric calculations; Thermodynamics; Chemical kinetics; Adsorption and Catalysis; Acids, bases and salts, concept of chemical equilibrium and ionic equilibrium; solubility products; solutes and solvents; Nernst Distribution Law; Redox reactions; Concepts of pH and pE; Electrochemistry; Chemistry of colloidal suspensions; Coordination chemistry; Basics of nuclear chemistry; Basic concepts of organic chemistry, hydrocarbons, aliphatic and aromatic compounds, organic functional groups, polarity of the functional groups; Xenobiotics; Polymer chemistry.

Unit II: Atmospheric chemistry **(10L)**

Composition of air; Particles, ions and radicals in the atmosphere; Chemical speciation; Chemistry of Free radicals; Chemical processes in the formation of inorganic and organic particulate matters, thermochemical and photochemical reactions in the atmosphere, Oxygen and Ozone chemistry. Photochemical smog, types of smog (sulphur smog and photochemical smog), aerosols; chemistry of acid rain, reactions of NO_X and SO_X; free radicals and ozone layer depletion, role of CFCs in ozone depletion.

Unit III: Water Chemistry **(5L)**

Hydrosphere and Hydrological cycle; Chemical and physical properties of water; Gases in water; Henry's Law; Amphoteric nature of water; Water as a universal solvent; Electrical conductivity; Hardness; Carbonate equilibria; Colloids in water; Concept of DO, BOD and COD; Sodium absorption ratio; Clathrate hydrates; Isotopologues of water. Important metals and non-metals in water: Pb, Cd, As, Hg, F: Sources, chemical speciation, effect on health; Case studies : Arsenic problems in W.B. and India, Fluorosis in Indian context

Unit IV: Soil Chemistry **(5L)**

Soils around us; Pedogenesis; Soil composition and classification; Soil profile; Soil water; Soil and the hydrologic cycle; Soil aeration and temperature; Soil acidity; Alkalinity, acidity and sodicity, Soil organic matter; N, S, P, K, Ca, Mg in soil; Sodium absorption ratio in soil, relation between organic carbon and organic matter; soil humus; cation and anion exchange reactions in soil; Nutrient management; Soil erosion; Role geotextiles in improving soil conditions; Different types of fertilizers.

Unit V: Common toxic chemicals(5L)

Pesticides and their classification; General introduction to pesticides (natural and synthetic), benefits and adverse effects, changing concepts of pesticides, structure activity relationship, synthesis and technical manufacture and uses of representative pesticides in the following classes: Organochlorines (DDT, Gammaxene,); Organophosphates (Malathion, Parathion); Carbamates (Carbofuran and carbaryl); Quinones (Chloranil), Anilides (Alachlor and Butachlor); Endocrine disrupting chemicals, PAH, VOC and other POPs; Carcinogens in the air.

Unit VI: Titrimetric and thermo-gravimetric methods of analysis **(5L)**

What is titration; Basic principle of Acid-base titration, Redox titration, Gravimetric titration, Complexometric titration, pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points; Properties of a good indicator; Theory of thermogravimetry (TG), basic principle.

Text Books:

1. Manahan S. Environmental Chemistry
2. Banerjee SK. Environmental Chemistry.
3. Dara SS. A text book of Environmental Chemistry and Pollution Control.
4. De AK. Environmental Chemistry. New Age (P) Ltd.
5. Jadhav HV. Elements of Environmental Chemistry

Reference Books:

1. Moore JW, Moore EA. Environmental Chemistry
2. Peavy HS, Rowe DR. Environmental Engineering. McGraw Hill.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Environmental Chemistry Course Code : SEN51103		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO 1	Identify key environmental compartments and processes in the air, water and soil.	**PO1, PO2, PO3, PO4, PO7, PO5, PSO3**
CO 2	Examine presence and fate of chemicals in the environment through use of field instrumentation, computer models, data analysis.	**PO1, PO2, PO3, PO4, PO5, PO7, PSO2**
CO 3	Explain the theoretical basis and observational methods for study of contaminants and interactions with the land surface, biota and climate change.	**PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9**
CO 4	Identify the major transport mechanisms of pollutants in the environment.	**PO1, PO2, PO3, PO5, PO7, PO8, PSO1**
CO 5	Compare chemical properties for toxicants and xenobiotics of environmental concern.	**PO1, PO2, PO3, PO4, PO5, PO7, PO8, PSO5**

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	**Internal**	**Attendance**	**Mid Term**	**End Term**
Weightage (%)	**30**	**10**	**20**	**40**

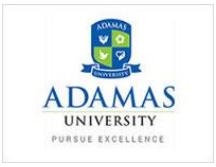
		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	**Knowledge hunting:** Students will be able to locate, evaluate and synthesize information from the scientific literature.	**Project management:** Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	**Interdisciplinary frame of mind:** Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource management, and	**Ethical approach:** Students will understand key concepts in the life and physical sciences and will apply them to environmental issues.	**Advanced tools:** Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	**Environmental monitoring:** To provide practical training on modern instrumentation and analytical techniques	**Research aptitude:** Students will be enabled to carry out an applied research project in the natural sciences.	**Professional growth:** Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
SEN51103	**Environmental Chemistry**	3	3	3	3	2	1	3	3	3	2	1	2	3	-

1 = weakly mapped

2 = moderately mapped

3 = strongly mapped

Model Question Paper

Name: **Enrolment No:**	

Course: SEN51103 – Environmental Chemistry

Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**
Semester: Odd 2020-21 **Max. Marks: 40**
Total no. of questions: 12

Instructions:
Attempt all (five) questions from **Section A** (each carrying 2 marks); any **Four Questions** from **Section B** (each carrying 5 marks); any one question from **Section C** (carrying 10 marks)**.**

Section A (Attempt **all the questions)**			
1.	Discuss the Nernst Distribution Law.	**R**	**CO3**
2.	A sample of steel containing sulphur has been taken for analysis. The sulphur of the sample is converted to H_2S which is absorbed in 10 mL of 0.005 M of I_2 where the following reaction is occurred: $H_2S + I_2 \rightarrow S + 2I^- + 2H^+$. The excess I_2 is titrated with 0.002 M of $S_2O_3^{2-}$ solution according to the following reaction : $I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$ If the volume of $S_2O_3^{2-}$ solution at the equivalent point is equal to 2.5 mL , calculate the mg weight of sulphur in the sample ?	**Ap**	**CO1**
3.	What do you mean by soil humus?	**U**	**CO2**
4.	What is the importance of BOD/COD ratio?	**E**	**CO4**
5.	What are endocrine disrupting chemicals?	**U**	**CO5**
Section B (Attempt any **four questions)**			
6.	Name one environmental application of complexometric titration. What do you mean by denticity of a ligand? Why is EDTA commonly used as titrant? (**1+1+3 = 5)**	**R**	**CO1**
7.	Explain in detail the nitrogen cycle.	**R**	**CO5**
8.	Explain in detail (with suitable examples) how polarity of a pollutant affects its environmental mobility and bioaccumulation potential. What do you mean by biomagnification? (**3+2=5)**	**An**	**CO3**
9.	What do you mean by photochemical smog? Explain with suitable chemical reactions.	**U**	**CO2**
10.	How is the ecosystem analogous to a thermodynamic system?	**An**	**CO4**
Section C (Attempt any **one question)**			
11.	What are pesticides classified based on their molecular properties? How is chemical structure of pesticides linked to their toxicological chemistry? How does pesticides affect the soil organic matter? What do you mean by sodium absorption ratio of soil? (**3+3+3+1 = 10)**	**U**	**CO5**
12.	How is pH of any water body related to the carbonate equilibria? What do you mean by buffers? Explain the mechanism of acid and basic buffers? What do you mean by natural buffering in ponds and lakes? (**4+1+2+3 = 10)**	**Ap**	**CO3, CO4**

SEN51105	Atmospheric science	L	T	P	C
Version 1.0	**Contact Hours – 45**	3	0	0	3
Pre-requisites/Exposure	Basic physics, chemistry, and mathematics.				
Co-requisites	-				

Course Objectives

1. Evaluate the Earth's global energy balance, and its relations to Earth's albedo, or concentration of atmospheric greenhouse gases.
2. To describe and explain methods employed to measure climatologic elements.
3. To explain the general characteristics of weather maps, and further to become familiar with the temporal and spatial representation of meteorological variables (e.g. temperature, atmospheric pressure).
4. To explain natural and anthropogenic causes of climate change at multiple scales.
5. To have a basic knowledge about Indian climates.

Course Outcomes

On completion of this course, the students will be able to

CO1.	Estimate a surface energy balance at a particular location given incoming solar radiation, surface albedo and information about any relevant surface features.
CO2.	Explain which global processes and patterns redistribute heat and energy across the Earth.
CO3.	Explain the principles of meteorological instrumentation.
CO4.	Describe and explain the forces controlling air motion and the resultant types of wind patterns.
CO5.	Describe and explain the relationship between upper level circulation and surface pressure patterns.
CO6.	Describe atmospheric conditions contributing to air pollution and the anthropogenic implications of air pollution.
CO7.	Describe weather phenomena associated with warm, cold and occluded fronts atmospheric conditions associated with the formation of storms, hurricanes and tornadoes.
CO8.	Interpret results from studies of present climate, as well as a range of climate models and place these results in the context of 'global warming'.
CO9.	Understand the dynamics of Indian climatology.

Course Description: The atmosphere and climate are a critical part of the environment, and climatic variability and change are central to the issue of current and future global environmental change. This course is directed towards developing deeper understanding of climatic variability and change, and their importance to the environmental modelling and management. The course focuses on correlating the components of the climate system and factors that lead to changes in the environment around us. Topics are presented in order of increasing complexity, beginning with the global energy balance and radiative transfer in the atmosphere. An introduction to simple energy balance models is integrated into the discussion of the global energy balance and radiative transfer. Studies on the Indian climatology are also an important part of the curriculum.

Detailed syllabus

Unit I: Basic Atmospheric Science **(20L)**

Composition and structure of the atmosphere; Atmospheric thermodynamics; Concept of heat transfer; Insolation and heat budget; Radiation,Conduction, Convection; Effects of the atmosphere, Absorption, Scattering of light (Raleigh and Mie Scattering) and reflection; Global dimming; Earth's thermal environment and seasons; Geographic and seasonal variation in the radiative balance and Earth's macroclimates; Air pressure and atmospheric circulation; Walker Circulation, ENSO and other oceanic oscillations; Atmospheric motion; Coriolis Effect; Pressure belts of the earth; Ferrel's Law; Buy Ballot's Law; Types of winds; Jet-stream; Geostrophic wind field; ITCZ; Ocean currents; Atmospheric boundary layer; western disturbances; theories of the origin of monsoon; Types of rainfall; Frontogenesis, cyclones and anticyclones; System of classification of climates (Köppen, Thornthwaite, Trewartha); Pressure, temperature, precipitation, humidity, mixing ratio, saturation mixing ratio, Concept of temperature, Lapse rate (dry and moist adiabatic); Environmental lapse rate; Wind direction and velocity; Wind roses; atmospheric stability and mixing heights; temperature inversion; plume behaviour; Gaussian plume model.

Unit II: Meteorology **(10L)**

Atmospheric stability; Inversion and mixing height; Wind roses; Climate and weather; Scales of meteorology, pressure, temperature, precipitation, humidity, radiation and wind; Hydrometeorology; Biometeorology; Features of Tropical meteorology.

Unit III: Indian Climatology **(5L)**

Seasons of India; Climatic subtypes of India (Köppen, Stamp and Kendrew, Trewartha); Factors affecting Indian monsoon; Rainfall distribution and variability of rainfall.

Unit IV: Natural disasters **(5L)**

Floods; Floods management; Cloud bursts; Cyclones; Drought; Drought management;

Unit V: Climate change **(5L)**

Global warming; How natural and human changes in land cover and land use affect climate; Global climate model; Role of land surface hydrology and terrestrial vegetation in determining regional and global climate; Microclimate

Text Books

1. Singh, S., Climatology, Prayag Pustak Publication.
2. Lal D.S., Climatology, Sharda Pustak Bhawan.
3. Siddhartha, K., Climatology : Atmosphere Weather Climate, Kitab Mahal.
4. Critchfield, H.J., General Climatology, Pearson Education India.
5. Chandrasekhar, A., Basics of Atmospheric Science, Prentice Hall India Learning Private Limited.

Reference books

1. Lutgens, F.K., Tarbuck, E.J. and Tasa, D., Atmosphere: An Intro to Meteorology, Pearson Education India.
2. Malhotra, N., and Sen, S., Climatology, R.K. Books.
3. Barry, R. G. 2003. Atmosphere, Weather and Climate. Routledge Press, UK.
4. Boeker, E. & Grondelle, R. 2011. Environmental Physics: Sustainable Energy and Climate Change. Wiley.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Atmospheric science		**Course Code : SEN51105**
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO 1	Estimate a surface energy balance at a particular location given incoming solar radiation, surface albedo and information about any relevant surface features.	**PO1, PO2, PO3, PO4, PO8, PSO1, PSO3, PSO4**
CO 2	Explain which global processes and patterns redistribute heat and energy across the Earth.	**PO1, PO3, PO4, PO7, PSO2, PSO3**
CO 3	Explain the principles of meteorological instrumentation.	**PO2, PO4, PO6, PO8, PSO2, PSO5**
CO 4	Describe and explain the forces controlling air motion and the resultant types of wind patterns.	**PO3, PO5, PSO2, PSO4**
CO 5	Describe and explain the relationship between upper level circulation and surface pressure patterns.	**PO3, PO4, PO9, PSO3, PSO5**
CO 6	Describe atmospheric conditions contributing to air pollution and the anthropogenic implications of air pollution.	**PO5, PO8, PO9, PSO1, PSO2**
CO 7	Describe weather phenomena associated with warm, cold and occluded fronts atmospheric conditions associated with the formation of storms, hurricanes and tornadoes.	**PO3, PO5, PO7, PO8, PSO3, PSO5**
CO 8	Interpret results from studies of present climate, as well as a range of climate models and place these results in the context of 'global warming'.	**PO2, PO4, PO6, PO8, PSO2, PSO5**
CO 9	Understand the dynamics of Indian climatology.	**PO5, PO8, PO9, PSO1, PSO2**

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	**Internal**	**Attendance**	**Mid Term**	**End Term**
Weightage (%)	**30**	**10**	**20**	**40**

		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource management, and loss of biodiversity.	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental issues.	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
SEN51105	**Atmospheric science**	2	3	3	3	3	2	3	3	3	2	2	2	3	1

1 = weakly mapped

2 = moderately mapped

3 = strongly mapped

Model Question Paper

Name: **Enrolment No:**	

Course: SEN51105 – Atmospheric science

Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**
Semester: Odd 2020-21 **Max. Marks: 40**
Total no. of questions: 12

Instructions:
Attempt all (five) questions from **Section A** (each carrying 2 marks); any **Four Questions** from **Section B** (each carrying 5 marks); any one question from **Section C** (carrying 10 marks)**.**

Section A (Attempt **all the questions)**			
1.	Fog is cloud at ground level. Discuss for or against the statement.	**U**	**CO7**
2.	What is Beaufort scale?	**R**	**CO4**
3.	State the Ferrel's Law and Buy Ballots Law?	**R**	**CO5**
4.	What do you mean by cloud bursts?	**U**	**CO3**
5.	How is inversion related to air pollution?	**E**	**CO6**
Section B (Attempt any **four questions)**			
6.	With the help of an annotated diagram, explain the working principle of an anemometer.	**U**	**CO2**
7.	Discuss the different mechanisms of scattering of light in the atmosphere.	**U**	**CO1**
8.	Explain the term 'frontogenesis'. How is it related to cyclonic systems?	**R**	**CO3**
9.	Give reasons for the following: a. Many of the hot deserts of the world lie on the west side of a continent either between 20^0N and 30^0N or between 20^0S and 30^0S. b. El-Nino causes drought in the Indian subcontinent.	**C**	**CO8** **CO9**
10.	Describe the necessary favourable conditions for origin and development of thunderstorms.	**An**	**CO1**
Section C (Attempt any **one question)**			
11.	What is an ecological hot-spot? Write a note on Indian biodiversity to justify the fact that India is a megadiverse country.	**R**	**CO7**
12.	What do you mean by solar flux? Using the Stefan-Boltzmann Law, the total amount of energy (L) radiated by the sun each second. What do you mean by effective temperature of a planet? How is albedo related to the energy budget of the earth? Why does the atmosphere therefore get colder as we go up? (2+3+3+2 = 10)	**E**	**CO1**

SEN51107	Ecology and biodiversity	L	T	P	C
Version 1.0	**Contact Hours – 45**	3	0	0	3
Pre-requisites/Exposure	Basic physics, chemistry, biology and mathematics.				
Co-requisites	-				

Course Objectives

1. To understand the philosophy of ecological science and the scientific methods involved.
2. To classify ecosystems, their structure (trophic relationships, abiotic factors, and biomes) and function (energy flow and biogeochemical cycles), population growth and the factors influencing this growth; ecological succession and the role of environmental disturbance in this process.
3. To develop the ability to apply quantitative skills to analyse and interpret ecological data.
4. To gain an understanding of the questions that ecologists study, the methods they use, and the questions that remain unanswered.
5. To have a basic knowledge about Indian ecosystems.
6. Illustrate the importance of and quantify biodiversity.

Course Outcomes

On completion of this course, the students will be able to

CO1.	Describe the basic principles of ecology, including population ecology, community ecology, and ecosystem function.
CO2.	Illustrate the characteristics of the major biomes and ecosystems of the Earth.
CO3.	Evaluate the interrelationships between land, sea, the atmosphere and the living things that occupy these environments.
CO4.	Apply concepts of biological evolution to all course topics.
CO5.	Apply quantitative methods including the tools needed to manage and undertake advanced ecological data analysis.
CO6.	Perceive the basic causes behind the ongoing global decline in biodiversity based on recent research, and importance of conservation.
CO7.	Examine plant diversity and explain the process of photosynthesis, nutrient uptake, reproduction, and adaptation to the environment.
CO8.	Examine animal diversity and explain how structure and function regulate bioenergetic, physiological, behavioural processes, and adaptation to the environment.
CO9.	Analyse the biodiversity and ecosystem services concepts and their relevance for management of natural resources and a sustainable development

Course Description: Introduction to ecosystem structure, types and survey of biological diversity emphasizing variation leading to natural selection; introduction to ecological concepts within an evolutionary framework; a survey of ecosystems and global climate change. Development of scientific skills will be emphasized. Biodiversity the world over is under constant threat. The curriculum includes ecology of populations, communities, ecosystems, and their interactions with the natural environment, how communities and habitats respond to pressures. Our ecology and biodiversity study areas provide every student with a holistic view of conservation practice integrating the environmental and the human factors.

Detailed syllabus

Unit I: Types of Ecosystems **(5L)**

Basis of Ecosystem classification. Types of Ecosystems: Habitat ecology; Biomes: Forest classification in India (Champion and Seth, 1968); Soil as an ecosystem; Edaphic factors; Parasitic ecosystems; Theory of Island bio-geography.

Unit II: Fundamentals of Ecology **(10L)**

Ecology as an inter-disciplinary science; Ecosystem Structure and functions: Structures - Biotic and Abiotic components; Functions - Energy flow in ecosystems, energy flow models, food chains and food webs; Ecological succession; Connel-Slatyer; Model of ecological succession; Concept of ecotone, edge effects, ecological habitats and niche. Ecosystem stability and factors affecting stability; Ecosystem services; Biogeochemical cycles; Ecological productivity; Trophic structure and energy flow; Food web complexity, food-web patterns; Guild analysis; Keystone species; Flagship species; Umbrella species; Energy flow in an ecosystem.

Unit III: Population ecology **(10L)**

Characteristics of population; Absolutely density; Deme; Natality; Fertility vs fecundity; Mortality; Migration; Optimal Reproductive Tactics; Concept of carrying capacity; Population growth models; Deterministic vs stochastic growth models; Survivorship and life table; Population age structure; Populations, Population viability analysis; Metapopulation (Levin's model, metapopulation persistence time, correlated extinction); Mathematical model of Lotka and Volterra; Tilman's model; Gause's hypothesis; Fundamental niche vs Realized niche; Concept of 'r' and 'k' selected species; Predation; Herbivory and mutualism; Plant defence hypotheses; Overgrazing; Disease and parasitism; Compartment models with constant and variable population size; Transmission coefficient; Red queen hypothesis; Regulation of population size; Alee effect; Source and sink population; Evolutionary implications of population regulation; Applied problem: Pest control and Integrated Pest Management, Distribution and abundance, Ecological specialisation models; Hanski's Rule; Local population model;

Unit IV: Community ecology **(10L)**

Biotic interactions; Community development; Co-evolution; Evolution of cooperation; Group selection; Interspecific competition and coexistence; Predation, herbivory, parasitism, allelopathy, mutualism, disease vs parasitism; commensalism, ammensalism, cooperation; Concept of niche; Eltonian, Grinnellian and Hutchinsonian concept; Niche overlapping; Niche breadth and width.

Unit V: Behavioural and physiological ecology **(5L)**

Ecological adaptations; Group selection; Kin selection; Cost-Benefit Analysis in behaviour; Foraging; Migration; Group living; Liebig's Law of the Minimum; Shelford's Law of Tolerance; Thermal Regulation, Allen's Rule and Bergmann's Rule; Factors that limit distribution of species (biotic and abiotic); Climate change and species distribution, Rapoports's Rule; Generalists vs Specialists.

Unit VI: Biodiversity **(5L)**

Genetic, species and ecosystem diversity; α, β and γ diversity; Measurement of biodiversity and biodiversity indices; Hotspots of biodiversity; Factors causing diversity gradients; Wildlife Protection Act, 1972; Conservation biology; Threats to biodiversity; Framework of biodiversity conservation in India; IUCN Conservation status; Red data Book; Concepts of gene pool, biopiracy and bio-prospecting, concept of Bio-patents; People's biodiversity register; Concept of restoration ecology; Extinct, Rare, Endangered and Threatened flora and fauna of India; Tools for wildlife research; Wildlife management; Use of Radiotelemetry and Remote sensing in wildlife research.

Text Books

1. Enger E, Smith B. Environmental Science. A Study of Interrelationships. McGraw-Hill Higher Education
2. Chapman, Reiss. Ecology: Principles and Applications. Cambridge University Press.
3. Kormondy EJ. Concept of Ecology. Prentice hall of India.
4. Kumar HD. Modern concepts in Ecology
5. Kormondy EJ. Concept of Ecology. Prentice hall of India.
6. Kumar HD. Modern concepts in Ecology

Reference books

1. Odum EP. Fundamentals of Ecology
2. Sharma PD. Ecology and Environment. Rastogi Publication.
3. Das MC. Fundamental of Ecology. Tata Mcgraw Hill Publication.
4. Gaston, KJ. & Spicer, J.I. 1998. Biodiversity: An Introduction. Blackwell Science,
5. London,
6. UK. Krishnamurthy, K.V. 2004. An Advanced Text Book of Biodiversity - Principles
7. and Practices. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi
8. Maiti, Maiti. Biodiversity: Perception, Peril and Preservation. PHI Learning Pvt. Ltd.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Ecology and biodiversity		**Course Code : SEN51107**
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO 1	Describe the basic principles of ecology, including population ecology, community ecology, and ecosystem function.	**PO1, PO2, PO3, PO4, PO8, PSO1, PSO3, PSO4**
CO 2	Illustrate the characteristics of the major biomes and ecosystems of the Earth.	**PO1, PO3, PO4, PO7, PSO2, PSO3**
CO 3	Evaluate the interrelationships between land, sea, the atmosphere and the living things that occupy these environments.	**PO2, PO4, PO6, PO8, PSO2, PSO5**
CO 4	Apply concepts of biological evolution to all course topics.	**PO3, PO5, PSO2, PSO4**
CO 5	Apply quantitative methods including the tools needed to manage and undertake advanced ecological data analysis.	**PO3, PO4, PO9, PSO3, PSO5**

	.	
CO 6	Perceive the basic causes behind the ongoing global decline in biodiversity based on recent research.	**PO5, PO8, PO9, PSO1, PSO2**
CO 7	Examine plant diversity and explain the process of photosynthesis, nutrient uptake, reproduction, and adaptation to the environment.	**PO3, PO5, PO7, PO8, PSO3, PSO5**
CO 8	Examine animal diversity and explain how structure and function regulate bioenergetic, physiological, behavioural processes, and adaptation to the environment.	**PO2, PO4, PO6, PO8, PSO2, PSO5**
CO 9	Analyse the biodiversity and ecosystem services concepts to determine their relevance in management of natural resources and a sustainable development.	**PO5, PO8, PO9, PSO1, PSO2**

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	Internal	Attendance	Mid Term	End Term
Weightage (%)	**30**	**10**	**20**	**40**

		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource management, and loss of biodiversity.	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental issues.	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
SEN51107	**Ecology and biodiversity**	2	3	2	3	3	1	3	3	3	2	2	2	3	1

1 = weakly mapped

2 = moderately mapped

3 = strongly mapped

Model Question Paper

Name: **Enrolment No:**	

Course: SEN51107 – Ecology and biodiversity

Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**
Semester: Odd 2020-21 **Max. Marks: 40**
Total no. of questions: 12

Instructions:
Attempt all (five) questions from **Section A** (each carrying 2 marks); any **Four Questions** from **Section B** (each carrying 5 marks); any one question from **Section C** (carrying 10 marks)**.**

Section A (Attempt **all the questions)**			
1.	Differentiate between habitat and niche.	**U**	**CO1**
2.	Discuss Liebig's Law in the context of concept of limiting factor.	**E**	**CO3**
3.	Differentiate between r and k selected species.	**U**	**CO1**
4.	What are bioindicators? Give an example.	**R**	**CO7**
5.	Differentiate between ex-situ and in-situ modes of conservation.	**An**	**CO6**
Section B (Attempt any **four questions)**			
6.	With the help of an annotated diagram, explain how different interacting and interrelated food chains give rise to a food web.	**C**	**CO1**
7.	Justify the statement "Succession plays a very important role in ecosystem restoration".	**An**	**CO9**
8.	Explain the concept of biomagnification using an ecological pyramid.	**Ap**	**CO3**
9.	What are the impacts of climate change on coral reefs. Explain your answer with an example of a coral reef in India.	**R/ E**	**CO9**
10.	What is Neo-Darwinism? Briefly describe the types of selection based on phenotype characteristics.	**Ap**	**CO4**
Section C (Attempt any **one question)**			
11.	Write a short notes on : (a) Acclimatization vs adaptation (b) Levin's metapopulation model.	**U/ R**	**CO5 CO7**
12.	Write a short note on energy flow in an ecosystem.	**U**	**CO2**

SEN51109	Natural Resources and Environment	L	T	P	C
Version 1.0	Contact Hours – 30	2	0	0	2
Pre-requisites/Exposure	Basic physics, chemistry, biology and mathematics.				
Co-requisites	-				

Course Objectives

1. To understand the importance of limited availability of natural resources.
2. To classify various types of resources.
3. To develop newer modalities of management of natural resources.
4. To have a basic knowledge about natural resources of India.
5. Illustrate the importance of overexploitation and allied ecosystem degradation.

Course Outcomes

On completion of this course, the students will be able to

CO1.	Integrate principles of biological, chemical, physical, and social sciences and apply them to resource and environmental issues using a systems approach.
CO2.	Understand ecological principles underpinning management of resources, populations, communities, and ecosystems.
CO3.	Use data collection and analysis tools to develop plans for managing resource/environmental challenges and adapt plans in response to rapid change.
CO4.	Understand the policies governing resources and the environment and identify social dimensions (stakeholders, interests, trade-offs, synergies, ethical principles) to consider in the development of management plans.
CO5.	Recognize how diverse groups understand the environment, experience positive and negative environmental impacts, and perceive just and equitable solutions.
CO6.	Identify and explain conceptual frameworks from the social sciences and ethics as they apply to interpreting human interactions with environment and natural resources
CO7.	Analyse collective human processes related to the environment/natural resources in depth and at varied scales (e.g. individual, community, institutional, global) using conceptual frameworks.
CO8.	Critically evaluate current events and public information related to natural resources as being scientifically-based or opinion-based and contribute to the knowledge base of information.

Course Description:

This course in natural resource covers techniques for maintaining and building a species with the goal of removing it from endangerment. Students explore how people introduce new species to an area without understanding how their presence affects the pre-existing ecosystem. One specific ecosystem covered is the forest. Students taking this natural resource management class learn specific ways that human interaction with forests has affected the ecosystem. Food, minerals, and water resources are also included. Problems associated with the use/misuse of our natural resources and current management practices associated with the conservation of natural resources will be discussed in detail. This course also examines the need for laws and policies regarding natural resources.

Detailed syllabus

Unit I: Forest Resources **(5L)**

Functions of forest resources, Ecological importance of forest resources, Economical importance of forest resources, Forest cover in India, Types of forests in India, Use and over exploitation of forests, Forest degradation, Deforestation, Afforestation, Sustainable Forest Management, Joint Forest Management, Protected Area Networks, National Forest Policy, Human wildlife conflict, Tribes and forests.

Unit II: Land Resources **(5L)**

Ecosystem services provided by land resources, Conversion and modification of land cover, Soil structure, Destruction of soil, Land potentiality, Land suitability, Land capability, Land use planning, Classification of land use, Grazing land, Agricultural cropland, Wasteland, Wetland, Watersheds, Degradation of land, Sustainable Land Management.

Unit III: Mineral Resources **(10L)**

Mineral resources from the Earth's crust, Rock cycle, Sources and demands of mineral resources, Types of mineral resources, Environmental impacts of mineral exploitation, Environmental impacts of mining, Reserves and mineral resources in India, Exploratory techniques of mineral resources, Recycling of mineral resources.

Unit IV: Food Resources **(5L)**

Types of food production, Sources of food, Problems associated with food production, Green revolution, Environmental impacts of modern agriculture, Sustainable agriculture practices, Food security in India, Global scarcity of food resources.

Unit V: Water Resources **(5L)**

Hydrological cycle and processes: Systems concept of hydrological cycle; Precipitation; Evaporation and transpiration; Runoff; Base flow; Infiltration; Types of water; Origin and composition of sea water; Origin of ground water; Subsurface profile of groundwater; Water bearing characteristics of different types of rocks; Geomorphic and geologic controls of ground water; Distribution of water in earth, hydrology and hydrogeology, major basins and groundwater provinces of India; groundwater tracers, land subsidence, effects of excessive use of groundwater, groundwater quality; Pollution of groundwater resources, Ghyben-Herzberg relation between fresh-saline water; Rivers of India; Watershed management

Text Books

1. Enger E, Smith B. Environmental Science. A Study of Interrelationships. McGraw-Hill Higher Education
2. Jetli, K,N., Mineral Resources and Policy in India, Ingram short title; 1st edition (1 January 2011).
3. Chiras, D.D., Natural Resource Conservation, Pearson Education; 10 edition (1 January 2014).
4. Misra, H.N., Managing Natural Resources: Focus on Land and Water, Prentice Hall India Learning Private Limited.

5. Chander,S. and Prasad, R.K., Water Resources Systems, Jain Brothers.
6. Asawa, G.L., Irrigation and Water Resources Engineering, New Age Publishers.
7. Pangannavar, A.Y., Forest Resources of India: Problems, Policies & Initiatives, New Century Publications.

Reference books

1. Sankar, A. Environmental Management. Oxford University Press.
2. Revuelta, M.B., Mineral Resources: From Exploration to Sustainability Assessment (Springer Textbooks in Earth Sciences, Geography and Environment)
3. Conrad, J.M., Natural Resource Economics: Notes and Problems, Cambridge University Press
4. Todd, D.K. and Mays, L.W., Groundwater Hydrology, Wiley India Pvt Ltd.
5. The Development of India's Forest Resources, FRI.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Natural Resources and Environment		**Course Code : SEN51109**
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO 1	Integrate principles of biological, chemical, physical, and social sciences and apply them to resource and environmental issues using a systems approach.	**PO1, PO2, PO3, PO4, PO8, PSO1, PSO3, PSO4**
CO 2	Understand ecological principles underpinning management of resources, populations, communities, and ecosystems.	**PO1, PO3, PO4, PO7, PSO2, PSO3**
CO 3	Use data collection and analysis tools to develop plans for managing resource/environmental challenges and adapt plans in response to rapid change.	**PO2, PO4, PO6, PO8, PSO2, PSO5**
CO 4	Understand the policies governing resources and the environment and identify social dimensions (stakeholders, interests, trade-offs, synergies, ethical principles) to consider in the development of management plans.	**PO3, PO5, PSO2, PSO4**
CO 5	Recognize how diverse groups understand the environment, experience positive and negative environmental impacts, and perceive just and equitable solutions..	**PO3, PO4, PO9, PSO3, PSO5**
CO 6	Identify and explain conceptual frameworks from the social sciences and ethics as they apply to interpreting human interactions with environment and natural resources	**PO5, PO8, PO9, PSO1, PSO2**
CO 7	Analyse collective human processes related to the environment/natural resources in depth and at varied scales (e.g. individual, community, institutional, global) using conceptual frameworks.	**PO3, PO5, PO7, PO8, PSO3, PSO5**
CO 8	Critically evaluate current events and public information related to natural resources as being scientifically-based or opinion-based and contribute to the knowledge base of information.	**PO2, PO4, PO6, PO8, PSO2, PSO5**

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	Internal	Attendance	Mid Term	End Term
Weightage (%)	30	10	20	40

		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource management, and loss of biodiversity.	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental issues.	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
SEN51109	**Natural Resources and Environment**	2	2	2	3	3	2	2	3	3	3	2	2	1	1

1 = weakly mapped

2 = moderately mapped

3 = strongly mapped

Model Question Paper

Name: **Enrolment No:**	

Course: SEN51109 – Natural Resources and Environment

Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**
Semester: Odd 2020-21 **Max. Marks: 40**
Total no. of questions: 12

Instructions:
Attempt all (five) questions from **Section A** (each carrying 2 marks); any **Four Questions** from **Section B** (each carrying 5 marks); any one question from **Section C** (carrying 10 marks)**.**

Section A (Attempt **all the questions)**			
1.	What do you mean by protected area network?	**U**	**CO1**
2.	Mention any two examples of successful implementation of JFM.	**E**	**CO3**
3.	Differentiate between land cover and land use.	**U**	**CO1**
4.	Mention any two environmental impacts of mineral exploration.	**R**	**CO7**
5.	Differentiate between aquitard and aquiclude.	**An**	**CO6**
Section B (Attempt any **four questions)**			
6.	Mention the two most important anthropogenic causes of salt water intrusion. With the help of an annotated diagram, explain the significance of Ghyben-Herzberg relation in the context of saltwater intrusion. (2+3)	**C**	**CO1**
7.	Justify the statement "Green revolution has ensured food security in India".	**An**	**CO9**
8.	Examine the adverse impacts of excessive sand mining on the river ecosystem.	**Ap**	**CO3**
9.	What do you mean by resilience based land management? Elaborate on any three drivers of land use change.	**R/ E**	**CO9**
10.	Elucidate the ecological significance of the National Forest Policy, 1988.	**Ap**	**CO4**
Section C (Attempt any **one question)**			
11.	Describe the of hydrological cycle indicating a. Precipitation; b. Evaporation and transpiration; c. Runoff; d. Base flow; e. Infiltration;	**U/ R**	**CO5 CO7**
12.	Do you think a National Land Use Policy should be formulated urgently? Substantiate your views.	**U**	**CO2**

SEN51201	Environmental chemistry Lab	L	T	P	C
Version 1.0	**Contact Hours – 120**	0	0	8	4
Pre-requisites/Exposure	Basic physics, chemistry, biology and mathematics.				
Co-requisites	-				

Course Objectives

1. To provide the key knowledge base and laboratory resources to prepare students for careers as professionals in the field of environmental science.
2. To enable the student to function as a member of an interdisciplinary problem-solving team.
3. To understand the fundamental principles behind different analytical procedures.
4. To enable the students to design and carry out scientific experiments as well as accurately record and analyse the results of such experiments
5. To help the students appreciate the central role of chemistry in our society and use this as a basis for ethical behaviour in issues facing chemists including an understanding of safe handling of chemicals, environmental issues and key issues facing our society in energy, health and medicine..

Course Outcomes

On completion of this course, the students will be able to

CO1.	Explore new areas of research in both chemistry and allied fields of science and technology.
CO2.	Illustrate expertise in volumetric calculation.
CO3.	Categorize different types of titration procedures.
CO4.	Understand the importance of chemical kinetics, ionic equilibrium and redox chemistry in analytical chemistry.
CO5.	Use data collection and analysis tools to develop plans for managing resource/environmental challenges and adapt plans in response to rapid change.

Course Description:

In this course students will learn basic techniques for chemical analysis of environmental samples. Students will also learn to utilize electronic data acquisition systems and further develop their scientific writing skills.

List of Experiments:

1. Estimation of strength of carbonate and hydroxide present together in mixture.
2. Estimation of carbonate and bicarbonate present together in a mixture.
3. Study of kinetics of decomposition of H_2O_2
4. Determination of solubility of sparingly soluble salt in water, in electrolyte with common ions and in neutral electrolyte (using common indicator).
5. Estimation of available chlorine in bleaching powder.
6. Verification of Ostwald's dilution law and determination of K_a of weak acid.
7. Detection of the following functional groups by systematic chemical tests: aromatic amino ($-NH_2$), aromatic nitro ($-NO_2$), amido ($-CONH_2$, including imide), phenolic –

OH, carboxylic acid (-COOH), carbonyl (distinguish between -CHO and >C=O); only one test for each functional group is to be reported.

8. Determination of exchange capacity of cation exchange resins and anion exchange resins.
9. Titrimetric estimation of acidity and alkalinity of water.
10. Estimation of hardness (Calcium, Magnesium and total) in water.
11. Titrimetric estimation of chloride in water.
12. Estimation of Dissolved Oxygen in water.

Reference Books:

1. Vogel's Text Book of Practical Organic Chemistry (5th Edition)
2. A Handbook of Organic Analysis: Qualitative and Quantitative (4th Edition) -Clarke
3. Standard Methods for the Examination of Water, American Public Health Association, American Water Works Association, Water Environment Federation

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Environmental chemistry Lab		**Course Code : SEN51201**
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO 1	Explore new areas of research in both chemistry and allied fields of science and technology.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 2	Illustrate expertise in volumetric calculation.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 3	Categorize different types of titration procedures.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 4	Understand the importance of chemical kinetics, ionic equilibrium and redox chemistry in analytical chemistry.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 5	Use data collection and analysis tools to develop plans for managing resource/environmental challenges and adapt plans in response to rapid change.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	**Mid Term**	**Attendance**	**Class Assessment**	**End Term**
Weightage (%)	**20**	**10**	**30**	**40**

		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource management, and loss of biodiversity.	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental issues.	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
SEN51201	**Environmental chemistry Lab**	2	2	2	2	-	2	3	3	3	3	2	2	3	-

1 = weakly mapped

2 = moderately mapped

3 = strongly mapped

Model Question Paper

Name: **Enrolment No:**	ADAMAS UNIVERSITY PURSUE EXCELLENCE

Course: SEN51201 – Environmental chemistry Lab

Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**
Semester: Odd 2020-21 **Max. Marks: 40**
Total no. of questions: 12

Instructions:
Attempt all questions**.**

Section A (Attempt **all the questions)**

1.	Obtain 20 mL of 0.10 M ammonia solution and 30 mL of 0.10 M HCl solution from the reagent station.	An	CO2
2.	Calculate the pH of the prepared buffer if 0.50 mL of 1.0 M HCl is added to 50 mL of the buffer. Plot a labelled titration curve using the data obtained and indicate the following: a. Chemical species before the titration was begun. b. Buffer region c. Chemical composition of the buffer d. Half equivalence point and equivalence point e. Chemical composition beyond the equivalence point.	E	CO1
3.	The concentrations of HCl and NaOH solutions used in the neutralization reaction are approximately equivalent, yet the volumes of HCl and NaOH solutions used in the reaction are not equal. Explain why	An	CO2
4.	List the important sources of error in this experiment and explain what effect each would have on the results. Discuss in particular any errors which you may have made	An	CO3
5.	What does the pH measure? Discuss effect of temperature on pH measurement.	E	CO4
6.	What are the precautions should be taken to measure pH of a solution?	Ev	CO3, CO5
7.	Estimate of strength of carbonate and hydroxide present together in the suppled mixture.	AN	CO5
8.	You measure the pH of a 0.50 M unknown acid solution using a pH meter and it is found to be 1.74. What is Ka for the acid? Show your calculations.	R, AP	CO4, CO5
9.	What are the precautions should be taken to measure pH of a solution?	E	CO3, CO5

SEN51203	Ecology Lab	L	T	P	C
Version 1.0	**Contact Hours – 90**	0	0	6	3
Pre-requisites/Exposure	Basic physics, chemistry, biology and mathematics.				
Co-requisites	-				

Course Objectives

1. Ecology laboratory is designed to give the student personal experience using scientific methods appropriate to any educated citizen active in community environmental concerns.
2. To provide the key knowledge base and laboratory resources to prepare students for careers as professionals in the field of environmental science.
3. To enable the student to function as a member of an interdisciplinary problem-solving team.
4. To enable the students to teach with a broad understanding of all content and understand the interaction between the sciences and the process skills as it relates to the interdependence of organisms.
5. To enable the students to design and carry out scientific experiments as well as accurately record and analyse the results of such experiments
6. To develop newer modalities of management of ecosystems.

Course Outcomes

On completion of this course, the students will be able to

CO1.	Apply the basic principles of ecological sampling.
CO2.	Make observations and interpretations of organism environment relationships and analyze data statistically and graphically.
CO3.	Demonstrate skills in the basic ecological investigative techniques included in this course.
CO4.	Identify the major groups and their respective dominant members in local terrestrial and aquatic ecosystems.
CO5.	Write reports that are neat, legible, well organized, grammatically correct, interesting, and ecologically sound.
CO6.	Effectively use field guides and technical manuals to identify specimens of common plants and animals.
CO7.	Identify some common insects and birds.
CO8.	Demonstrate qualitative and quantitative ecological studies.

Course Description:

In this course students will learn basic techniques for undergoing ecological studies. Students will also learn to utilize electronic data acquisition systems and further develop their scientific writing skills.

List of Experiments

1. How to plan an ecological research programme and how to develop workable data sheets.
2. Understanding the fundamental principles of sampling.
3. Methods for studying plant communities.

4. Methods for studying invertebrates.
5. Methods for studying birds and mammals.
6. Layout of experimental design and statistical analysis.
7. Study of population and community ecology of aquatic and terrestrial ecosystem and biodiversity documentation.
8. Study of abiotic environmental factors/variables.

Reference Books:

1. Practical Methods in Ecology, Henderson P.A., Blackwell Publishing.
2. Ecological Census Techniques: A Handbook, Ed. William J. Sutherland, Cambridge University Press.
3. Brower, J.E. and Zar, J.H. (1984) Field and Laboratory Methods for General Ecology. Brown, Dubuque, Iowa.
4. Cox, G.W. (1996) Laboratory Manual of General Ecology. Brown, Dubuque, Iowa.
5. Darnell, R.M. (1971) Organism and Environment: A Manual of Quantitative Ecology. Freeman, San Francisco.
6. Enger, E.D. and Smith, B.F. (1995) Field and Laboratory Activities in Environmental Science. Brown, Dubuque, Iowa.
7. Lynn, L.M. (1997) Environmental Biology and Ecology Laboratory Manual. Kendall/Hunt, Dubuque, Iowa.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Ecology Lab		**Course Code : SEN51103**
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO 1	Apply the basic principles of ecological sampling.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 2	Make observations and interpretations of organism environment relationships and analyze data statistically and graphically.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 3	Demonstrate skills in the basic ecological investigative techniques included in this course.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 4	Identify the major groups and their respective dominant members in local terrestrial and aquatic ecosystems.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 5	Write reports that are neat, legible, well organized, grammatically correct, interesting, and ecologically sound.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO6	Effectively use field guides and technical manuals to identify specimens of common plants and animals.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO7	Identify some common insects and birds.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**

CO8	Demonstrate qualitative and quantitative ecological studies.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	Mid Term	Attendance	Class Assessment	End Term
Weightage (%)	**20**	**10**	**30**	**40**

		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource management, and loss of biodiversity.	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental issues.	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
SEN51203	**Ecology Lab**	2	2	2	2	-	2	3	3	3	3	2	2	3	-

1 = weakly mapped

2 = moderately mapped

3 = strongly mapped

Model Question Paper

Name:

Enrolment No:

Course: SEN51203 – Ecology Lab

Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**

Semester: Odd 2020-21 **Max. Marks: 40**

Total no. of questions: 12

Instructions:
Attempt all questions**.**

Section A (Attempt **all the questions)**

1.	Looking at the 2 communities below, compare the species richness and the species diversity using the Simpson's Diversity Index. Note: For this activity, we will assume that each different morphotype of insect collected represents a species.	E	CO1

Community A		**Community B**	
Morphotype 1	1,000	Morphotype 1	400
Morphotype 2	100	Morphotype 2	400
Morphotype 3	100	Morphotype 3	400

a. Compare the species richness and diversities of the 4 different habitats studied.
b. What possible factors could have led to the difference between the habitats?
c. Which of the following habitats is more diverse: A habitat including 10 species, each represented by 2 individuals? Or a habitat including 10 species, 1 of which is represented by 85 individuals and the remaining 9 species represented by 1 individual each? Explain your answer.

2.	Within a homogeneous habitat, in which the organisms under study are normally distributed, what should be the the number of samples?	An	CO2
3.	What do you mean by stratified random sampling?	An	CO3
4.	What is the basic concept behind Mark–recapture methods for population size estimation?	R	CO4

5.	Taxon abundance grasshopper 35 garden spiders 12 fruitflies 8 wombats 1 jaberwockies 41 Total 97 Calculate Shannon-Wiener index.	E	CO3, CO5

SEN51701	Field visit	L	T	P	C
Version 1.0		x	x	x	2
Pre-requisites/Exposure	-				
Co-requisites	-				

Course Objectives

1. To learn the tools and techniques of conducting field survey.
2. To learn techniques of data collection, data analysis and report writing specific to physical and socio-economic issues of the selected study area.
3. To learn the basic skills required for disaster preparedness planning through field based case studies.

Course Outcomes

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

CO1.	Identify appropriate tools and techniques necessary to conduct field survey.
CO2.	Interpret physical and socio-economic status of the study area based on analysis of the collected data.
CO3.	Identify appropriate tools and techniques to prepare disaster preparedness plan.

Course Description: Field trips are enriching experiences for students to test their knowledge gained throughout the program. This course is designed to gain a new knowledge or clarifying concepts learned in the classroom. Field excursion will provide opportunities to the students to explore the knowledge of physical, social and cultural environment to find the solution for environmental pollution, economic development and social progress. Through this course students can foster interest and motivation to learn and research in various aspects of the subject. Concomitantly writing of the project and their oral presentation will help to improve their thinking, writing and communication skills. This course will consist of lectures, hands-on training to handle various field instruments, field visits, data collection, data analysis, report writing and presentation. The focus will be on enhancing problem identification capacity, data collection from field and their analysis. The majority of class will be invested on field, and in laboratory for data analysis and interpretation. Students will be given tasks for preparing questionnaires, data tabulation and analysis, laboratory testing, identifying and relating the factors for physical and social conditions. Submission of the prepared report and its presentation should be done by the students at the end of the course.

Course content

Visit and comprehensive study to any place of environmental importance.

Modes of Evaluation: Quiz/Assignment/Presentation/Extempore/Written Examination
Examination Scheme:

	Internal	Presentation Oral	Presentation Notebook	Understanding of the problem	Methodology for Field Investigation	Content	Analysis	Conclusion
Weightage (%)	**20**	**15**	**15**	**10**	**10**	**10**	**10**	**10**

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO1	Identify appropriate tools and techniques necessary to conduct field survey.	**PO4, PO6, PO9, PSO1**
CO2	Interpret physical and socio-economic status of the study area based on analysis of the collected data.	**PO4, PO5, PO6, PO7, PO9, PSO3**
CO3	Identify appropriate tools and techniques to prepare disaster preparedness plan.	**PO3, PO4, PO5, PO6, PO7, PO8, PO9, PSO3, PSO4**

		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource management, and loss of biodiversity.	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental issues.	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
SEN51701	**Field visit**	2	3	3	3	3	2	3	3	3	2	2	2	3	1

1 = weakly mapped

2 = moderately mapped

3 = strongly mapped

SMA51171	Mathematics Foundation	L	T	P	C
Version 1.0	**Contact Hours – 30**	2	0	0	2
Pre-requisites/Exposure	Basic mathematics.				
Co-requisites	-				

Course Objectives

1. To help the student to acquire basic knowledge of set theory and its application
2. To give the students ideas about different methods for solving linear and non-linear equations
3. To enable students acquire knowledge on matrix operations and its application for solving simultaneous linear equations
4. To enable the students to acquire elementary knowledge of calculus and its application on computation and optimization of different economic functions

Course Outcomes

On completion of this course, the students will be able to

CO1	**Define** various terms related to the theory of sets and its properties with Venn diagrams representations.
CO2.	**Illustrate** the solution of linear, nonlinear equations and the related problems including the study of Indices and Surds, logarithms, Arithmetic and Geometric progression.
CO3.	**Find** the inverse of a matrix, determinant, and the solution of a system of linear equations arises from simple business/economics applications.
CO4.	**Summarize** the theory and methods to determine the derivatives of a function of one and several variables.
CO5.	**Find** indefinite and definite integration.

Course Description: The course is designed for students of Environmental Science, economics, business studies and management. It assumes very little prerequisite knowledge, so the topics of this course can be understood by students who have not undertaken a mathematics course for some time. The focus of this course is to enable the students to apply basic mathematical tools to learn other subjects easily. By taking this course student will gain the concept of sets and different properties of sets. This course is intended to provide some tools for performing basic operations on matrices and use those tools for solving system of linear equations and matrix equations. Furthermore, some basic ideas about differentiation and integration of a given function are introduced in this course. It also includes some application of differentiation and integration. Also, a few well known functions and their properties are discussed through this course

Detailed syllabus

Unit I: Set Theory **(13L)**

Set theory: Theory of sets- meaning, elements, types, presentation and equality of sets, union, intersection, compliment & difference of sets, Venn diagrams, Cartesian product of two sets, applications of set theory, Linear equations: graphs of linear equations, algebraic solution of simultaneous linear equations, Algebra: Indices and Surds, logarithms, Arithmetic and Geometric progression, Nonlinear equations: quadratic, exponential and logarithmic equations.

Unit II: Matrix and Determinants **(7L)**

Matrices: Types, properties, addition, multiplication, transpose and inverse of matrix
Properties of determinants, solution of simultaneous linear equations, differentiation and integration of standard algebraic functions, business applications of matrices.

Unit III: Basics of Calculus **(10L)**

Differentiation and Integration: Derivative of a function, rules of differentiation, Partial differentiation, Indefinite integration, definite integration, Ordinary differential equation.

Test book:

1. Ian Jacques, Mathematics for and Economics and Business (Fifth edition), Pearson India.
2. D.C. Sancheti, V.K. Kapoor, Business Mathematics,.

Reference Book:

1. J.D. Gupta, P.K. Gupta, Man Mohan, Mathematics for Business and Economics, Tata McGraw Hill Publishing Company Ltd.
2. Q. Zameeruddin, V. K. Khanna, S. K. Bhambri, Business Mathematics (Second Edition), Vikas Publishing House PVT LTD.

Course Outcomes

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

Mathematics foundation Course Code : SMA51171		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO 1	**Define** various terms related to the theory of sets and its properties with Venn diagrams representations.	**PO1, PO4, PO9, PSO2**
CO 2	**Illustrate** the solution of linear, nonlinear equations and the related problems including the study of Indices and Surds, logarithms, Arithmetic and Geometric progression.	**PO1, PO4, PO9, PSO2**
CO 3	**Find** the inverse of a matrix, determinant, and the solution of a system of linear equations arises from simple business/economics applications.	**PO1, PO4, PO9, PSO2**
CO 4	**Summarize** the theory and methods to determine the derivatives of a function of one and several variables.	**PO1, PO4, PO9, PSO2**
CO 5	**Find** indefinite and definite integration.	**PO1**, **PO4, PO9, PSO2**

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	Internal	Attendance	Mid Term	End Term
Weightage (%)	30	10	20	40

		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems	**Knowledge hunting:** Students will be able to locate, evaluate and synthesize information from the scientific literature	**Project management:** Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	**Interdisciplinary frame of mind:** Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate	**Ethical approach:** Students will understand key concepts in the life and physical sciences and will apply them to environmental issues	**Advanced tools:** Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology	**Environmental monitoring:** To provide practical training on modern instrumentation and analytical techniques	**Research aptitude:** Students will be enabled to carry out an applied research project in the natural sciences.	**Professional growth:** Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	**Meaningful and socially useful employment**: To sensitize students towards environmental issues, and impacts	**Encourage innovation:** To encourage innovation that is exposure driven where students can apply their	**Professional training:** This course will enable the students to get exposed to the real-world situations through	**Scientific communication skills**: To prepare students in such a way so that they can communicate science	**Leadership qualities**: Postgraduate students will attain leadership quality to handle all kind of circumstancesin diversities by providing interdisciplinary and multidisciplinary learning environment withteam work
Course Code	Course Title	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO9	PSO 1	PSO 2	PSO 3	PSO 4	PSO5
SMA5117 1	**Mathematics Foundation**	3	-	-	3	-	-	-	-	-	-	3	-	-	-

1 = weakly mapped, 2 = moderately mapped, 3 = strongly mapped

Model Question Paper

Name: **Enrolment No:**	ADAMAS UNIVERSITY PURSUE EXCELLENCE

Course: SMA51171 – Mathematics Foundation

Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**
Semester: Odd 2020-21 **Max. Marks: 40**
Total no. of questions: 12

Instructions:
Attempt all (five) questions from **Section A** (each carrying 2 marks); any **Four Questions** from **Section B** (each carrying 5 marks); any one question from **Section C** (carrying 10 marks)**.**

	Section A (Attempt **all the questions)**		
1.	**What** is a set and how to define complement of a set?	**R**	**CO1**
2.	**Illustrate** the solution of the equation: $x^2 - 2x - 3 = 0$.	**U**	**CO2**
3.	**Find** the number of elements in $(A \cup B)$ and $(A \cap B)$, where A = $\{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ and B = $\{6, 8, 10, 12, 15, 19, 20, 25\}$	**R**	**CO3**
4.	**Find** the value of *x*, if $\frac{\log(125)}{\log(25)} = x$	**U**	**CO2**
5.	**What** is the sum of the first 50 terms of the arithmetic progression 4, 1, -2, … … …	**U**	**CO2**
	Section B (Attempt any **four questions)**		
6.	**What** is the value of $\int_0^1 (x^2 + x^5 + sinx + e^x)dx$	**R**	**CO5**
7.	**When** a matrix is said to be invertible? Write the inverse of the matrix $\begin{pmatrix} 1 & 3 \\ 5 & 9 \end{pmatrix}$.	**R**	**CO3**
8.	**Find** the valueof $\frac{\partial z}{\partial x}$, $\frac{\partial z}{\partial y}$ and $\frac{\partial^2 z}{\partial x \partial y}$ where z = $x^2y + y^5x^6 + sin(x)cos(y)$	**U**	**CO4**
9.	$A = \begin{pmatrix} 0 & 1 \\ 2 & 3 \end{pmatrix}, B = \begin{pmatrix} 1 & 2 \\ 3 & 4 \end{pmatrix}$. **Show** that $(A + B)' = A' + B'$.	**R**	**CO3**
10.	Using matrix method **find** the solution of the system of linear equations $2x + 3y = 1$ $x + 2y = 4$.	**R**	**CO3**

Section C (Attempt any **one question)**			
11.	**Find** the value of $\int x^3 e^{4x}\, dx$.	**R**	**CO5**
12.	**Summarize** the result of $\frac{\partial^2 z}{\partial x^2}$ and $\frac{\partial^2 z}{\partial y^2}$, where $z(x,y) = 10x^2 y^2 + 3x^3y^4$.	**U**	**CO4**

SEN51102	Air Pollution and control technologies	L	T	P	C
Version 1.0	**Contact Hours – 60**	4	0	0	4
Pre-requisites/Exposure	Basic physics, chemistry, and mathematics.				
Co-requisites	-				

Course Objectives

1. Define air pollution and its global implications.
2. Classify various air pollutants and their emission standards.
3. To describe and explain methods employed to measure different air pollutants.
4. To illustrate atmospheric stability classes via atmospheric dispersion modelling.
5. To demonstrate the air pollution control devices.
6. To determine the source, effects and control of noise pollution.
7. To measure and control of radiation relating disposal of radioactive waste.
8. To demonstrate odour pollution detection instruments along with odour characterization and its influence in odour pollution.

Course Outcomes

On completion of this course, the students will be able to

CO1.	Classify different types of air pollutants, their sources and effects on the environment, and their sampling/measurement techniques
CO2.	Demonstrate the principles of air pollution control devices.
CO3.	Explain the influence of meteorological phenomena on air quality and atmospheric dispersion modelling.
CO4.	Describe the source of noise pollution, their effects on the auditory system and health and to measure noise pollution.
CO5.	Understand impact of odour pollution with odour characteristics and odour pollution detection instrumentation.

Course Description: Air is never found clean in nature, due to natural and man-made pollution. Gases such as CO, SO_2 and H_2S are continually released into atmosphere through natural activities. In addition to these 'natural pollutants', there are man-made pollutants-gases, mists and particulates, aerosols resulting from the chemical and biological processes used by man. This course is directed towards understanding different types of primary and secondary air pollutants, their behaviour in the atmosphere, effects and their controlling strategies using different control devices. The course also focuses the effects and control measures of noise and radiation pollution. The course also proposes serious environmental issues like odour pollution, however due to the nature of the problem; even experts find it sometimes difficult to define the real cause of an unpleasant intense smell.

Detailed syllabus

Unit 1: Introduction (10 L)

History of Air pollution; Composition and structure of the atmosphere; Global implication of air pollution; Units of measurement; Sources of air pollution; Classification of pollutants; Particulates, Hydrocarbons, Carbon monoxide, Oxides of Sulphur, Oxides of nitrogen, photochemical oxidants; Air quality index and air quality standards, emission standards

Unit 2: Measurements of air pollution (10 L)

Representative sampling; Source testing; Batch measurements; Real-time measurements; Mass concentration; Size distribution; Isokinetic sampling; hi-volume samplers and cascade impactors; Gas measurements

Unit 3:Air pollution meteorology (15 L)

Influence of meteorological phenomena on air quality: atmospheric circulation patterns, atmospheric stability and vertical mixing, lapse rate and temperature inversions; Atmospheric dispersions modelling: atmospheric stability classes, Gaussian model, estimation of downwind concentrations, plume rise, tall stacks, and critical wind speed. Computer modelling, point source models, mobile and line sources models

Unit 4: Air Pollution Control (15 L)

Control devices for particulate contaminants: gravitational settling chambers, centrifugal collectors, wet collectors, fabric filters, electrostatic precipitators; Control devices for gaseous contaminants: adsorption, absorption, condensation, combustion, automotive emission control

Unit 5: Noise Pollution (5L)

Industrial noise -Sources, and its control, Effects of noise on the auditory system and health, Measurement of noise; Radiation Hazards: Types and effects of radiation on human body, Measurement and detection of radiation intensity, disposal of radioactive waste, Control of radiation, Vibration - effects, measurement and control measures.

Unit 6: Odour Pollution (5L)

Impacts of odour pollution; Odour as an Environmental Nuisance; Sources and dispersion of odours; Characteristics of Odour Molecules; Odour Dimensions (EPA, 2001); Odour pollution detection instrumentation; Olfactometry and Gas chromatography; Concepts of Total Odour Number (TON); Understanding Odour Characteristics; Molecular Mass, Volatility and Functional Groups; Odour Pollution Reduction Technologies.

Text Books

1. De A.K., Environmental Chemistry, New Age International Publishers.

2. Manahan, S.E., Environmental Chemistry, Lewis Publishers.
3. Natusch, D.F.S. and Hopke, P.K., Analytical Aspects of Environmental Chemistry, John Wiley & sons.

Reference books

1. Buch,W., Atmospheric Pollution, McGraw Hill.
2. Williamson, S.J., Fundamentals of Air Pollution, Addison-Wesley publishing Co.
3. Cadle, R.D. The Measurement of Air-borne Particles, John Wiley & sons.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Air Pollution and control technologies Course Code : SEN51102		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO 1	Classify different types of air pollutants, their sources and effects on the environment, and their sampling/measurement techniques	**PO2, PO4, PO5, PO8, PO9, PSO1, PSO3, PSO4**
CO 2	Demonstrate the principles of air pollution control devices.	**PO1, PO2, PO3, PO4, PO5, PO 6, PO7, PSO1, PSO3, PSO4**
CO 3	Explain the influence of meteorological phenomena on air quality and atmospheric dispersion modelling.	**PO1, PO2, PO4, PO6, PO7, PO8, PSO2, PSO3**
CO 4	Describe the source of noise pollution, their effects on the auditory system and health and to measure noise pollution.	**PO1, PO2, PO4, PO6, PO7, PSO1, PSO4**
CO 5	Understand impact of odour pollution with odour characteristics and odour pollution detection instrumentation.	**PO2, PO4, PO5, PO7, PSO2**

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	**Internal**	**Attendance**	**Mid Term**	**End Term**
Weightage (%)	**30**	**10**	**20**	**40**

		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource management, and loss of biodiversity.	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental issues.	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
SEN51102	**Air Pollution and control technologies**	2	3	3	3	3	2	3	3	3	2	2	2	3	1

1 = weakly mapped

2 = moderately mapped

3 = strongly mapped

Model Question Paper

Name: **Enrolment No:**	

Course: SEN51102 – Air Pollution and control technologies

Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**
Semester: Odd 2020-21 **Max. Marks: 40**
Total no. of questions: 12

Instructions:
Attempt all (five) questions from **Section A** (each carrying 2 marks); any **Four Questions** from **Section B** (each carrying 5 marks); any one question from **Section C** (carrying 10 marks)**.**

Section A (Attempt **all the questions)**			
1.	What is Gaussian Model?	**R**	**CO4**
2.	What is radiation dose?	**R**	**CO3**
3.	What is Olfactometry?	**R**	**CO1**
4.	What is Electrostatic Precipitator?	**U**	**CO3**
5.	What do you mean by isokinetic sampling?	**U**	**CO2**
Section B (Attempt any **four questions)**			
6.	What is acid rain? Describe the basic chemical reactions of acid rain with equations. (2+3=5)	**An**	**CO1**
7.	Suggest a few remedial technologies for removal of particulate air-pollutants.	**Ap**	**CO3**
8.	Explain greenhouse effect? What are the consequences of the greenhouse effect? (2+3=5)	**E**	**CO1**
9.	Briefly explain the different atmospheric stability classes.	**R**	**CO4**
10.	What are the measurement techniques of odour pollution?	**R**	**CO5**
Section C (Attempt any **one question)**			
11.	When do we consider air is polluted? What is air pollution? What are the adverse health and environmental impacts of air-pollution? (2+2+6=10)	**E**	**CO1**
12.	What is hydroxyl radical? What is its role in the formation of photochemical smog? Name the most important pollutant responsible for photochemical smog? What are the hazards of photochemical smog? How formation of photochemical smog can be avoided? (1+2+2+2+3=10)	**Ap**	**CO1**

SEN51104	Water Pollution and Control Technologies	L	T	P	C
Version 1.0	Contact Hours – 60	4	0	0	4
Pre-requisites/Exposure	Basic physics, chemistry, and mathematics.				
Co-requisites	-				

Course Objectives

1. To illustrate physical and chemical parameters of water quality and water pollution.
2. To interpret different water quality standards.
3. To describe various water purification processes in natural streams.
4. To analyse the metabolic processes in response to biodegradable organic waste in stream.
5. To classify various physical, chemical and biological water treatment processes.
6. To categorize wastewater treatment processes and wastewater characterization.

Course Outcomes

On completion of this course, the students will be able to

CO1.	Classify different types of water pollutants, their sources and effects on the environment.
CO2.	Demonstrate water sampling techniques and measurements of different water quality parameters.
CO3.	Categorize different water quality standards.
CO4.	Determine various physical, chemical and biological water treatment processes.
CO5.	Understand the dynamics of metabolic processes of biodegradable organic waste in stream.
CO6.	Demonstrate engineered systems associated with wastewater treatment processes.

Course Description: Water pollution is a state of deviation from the pure condition, whereby its normal function and properties are affected. This course is depicts a knowledge of aquatic environmental chemistry which is the key to the understanding of water pollution and its control. Water pollution can be best considered in the perspective of possible pollutant cycles throughout the environment. The course focuses the sampling and analysis of various physico-chemical parameters of water quality and the water quality standards according to their sources and uses. Besides physical, chemical and biological water treatments processes, demonstration of the engineered treatment processes of wastewater management most of which take place in industries are other important aspects of the course.

Detailed syllabus

Unit 1: Water Quality (10L)

Physical water quality parameters: suspended solids, turbidity, colour, taste and odor, temperature; Chemical water quality parameters: total dissolved solids, alkalinity, hardness, fluoride, metals, organic matters, nutrients; biological water quality parameters; Water

quality requirements: in- stream standards, potable water standards, wastewater effluent standards.

Unit 2: Water Purification Processes in Natural Streams (6L)

Dilution, sedimentation, filtration, gas transfer, heat transfer, chemical conversions, metabolic processes; Response of stream to biodegradable organic waste: Oxygen Sag Curve analysis.

Unit 3: Water Treatment Processes (24L)

Historical overview of water treatment; Introduction to physical unit operations: mixing and flocculation, sedimentation, gas transfer, filtration, membrane filtration, adsorption, gas stripping, disinfection; Biological treatment procedures; Introduction to chemical unit processes: coagulation, chemical precipitation, ion exchange, water stabilization, chemical oxidation.

Unit 4: Engineered systems for Wastewater Treatment (20L)

Wastewater characteristics; Wastewater flow-rate and constituent loading; Primary treatment: screening, grit removal, primary sedimentation; Secondary Treatment: introduction to biological treatment, growth and food utilization, suspended growth biological systems, activated sludge, completely mixed reactors, plug-flow reactors, design considerations, aeration ponds and lagoons; attached-culture systems: trickling filters, rotating biological reactors; Secondary clarification; Sludge treatment and disposal.

Text Books

1. De A.K., Environmental Chemistry, New Age International Publishers.
2. Manahan, S.E., Environmental Chemistry, Lewis Publishers.
3. Natusch, D.F.S. and Hopke, P.K., Analytical Aspects of Environmental Chemistry, John Wiley & sons.

Reference books

1. Sawyer, C., McCarty, P.L., and Parkin, G.F., Chemistry for Environmental Engineering and Science, McGraw Hill Education.
2. Metcalfe and Eddy, Wastewater Engineering, McGraw Hill Education.
3. Viessman, W. Jr., Hammer, H.J., Perez. E.M., and Chadik, P.A., Water Supply and Pollution Control, Pearson Prentice Hall.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Water Pollution and Control Technologies Course Code : SEN51104		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO 1	Classify different types of water pollutants, their sources and effects on the environment.	**PO 1, PO2, PO4, PO5, PO7, PO8, PO9, PSO1, PSO2, PSO5**
CO 2	Demonstrate water sampling techniques and measurements of different water quality parameters.	**PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO 8, PO9, PSO1, PSO3, PSO4**
CO 3	Categorize different water quality standards.	**PO2, PO3, PO5, PO7, PSO1, PSO4, PSO5**
CO 4	Determine various physical, chemical and biological water treatment processes.	**PO1, PO2, PO4, PO6, PO7, PO8, PSO1, PSO4, PSO5**
CO 5	Understand the dynamics of metabolic processes of biodegradable organic waste in stream.	**PO2, PO4, PO5, PO7, PSO 1, PSO2, PSO4**
CO 6	Demonstrate engineered systems associated with wastewater treatment processes.	**PO2, PO3, PO6, PO7, PSO1, PSO3, PSO4, PSO5**

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	**Internal**	**Attendance**	**Mid Term**	**End Term**
Weightage (%)	**30**	**10**	**20**	**40**

		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource management, and loss of biodiversity.	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental issues.	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
SEN51104	**Water Pollution and Control Technologies**	3	3	3	3	3	3	3	3	3	2	2	2	3	2

1 = weakly mapped

2 = moderately mapped

3 = strongly mapped

Model Question Paper

Name: **Enrolment No:**	ADAMAS UNIVERSITY PURSUE EXCELLENCE

Course: SEN51104 – Water Pollution and Control Technologies

Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**
Semester: Odd 2020-21 **Max. Marks: 40**
Total no. of questions: 12

Instructions:
Attempt all (five) questions from **Section A** (each carrying 2 marks); any **Four Questions** from **Section B** (each carrying 5 marks); any one question from **Section C** (carrying 10 marks)**.**

Section A (Attempt **all the questions)**			
1.	What is COD?		**CO2**
2.	What is fluorosis?		**CO1**
3.	What do you mean by Oxygen Sag Curve analysis?		**CO5**
4.	What are the physical parameters of water quality?		**CO2**
5.	What is DO?		**CO2**
Section B (Attempt any **four questions)**			
6.	What are the aerobic treatment processes? Discuss the distinguishing features of Activated Sludge Process. (2+3=5)		**CO6**
7.	Discuss some of the advantages of physico-chemical treatment of sewage as opposed to biological treatment. What are the relative disadvantages? (3+2=5)		**CO6**
8.	Give an account of the chemical treatment processes of water.		**CO4**
9.	Briefly describe the secondary treatment process of wastewater.		**CO6**
10.	Compare the advantages of aerobic and anaerobic processes.		**CO6**
Section C (Attempt any **one question)**			
11.	Explain the environmental chemistry of (a) Hg and (b) As, in an aquatic ecosystem.		**CO1**
12.	Describe methods for the estimation of the following parameters in water sample: (a) Nitrate and Nitrite (b) Phosphate (c) Biological Oxygen Demand (d) Hardness (e) Chromium (5x2=10)		**CO2**

SEN51106	Environmental Geosciences	L	T	P	C
Version 1.0	**Contact Hours – 45**	3	0	0	3
Pre-requisites/Exposure	Basic physics, chemistry, mathematics and geography.				
Co-requisites	-				

Course Objectives

1. To illustrate the fundamental concept of environmental geosciences.
2. To describe the theories of Earth's geodynamic processes.
3. To classify different rock types and rock cycle.
4. To develop the concept of physiography of land forms and geomorphology.
5. To develop the concept of Geochemistry and geochemical pathways.
6. Influence of hydrology and laws of ground water movement.
7. Function and principles of Remote Sensing and concept of GIS.

Course Outcomes

On completion of this course, the students will be able to

CO1.	Understand the geodynamic processes physicochemical and seismic properties of Earth, various catastrophic geophysical hazards and their impacts..
CO2.	Classify different types of rocks and minerals, rock cycle and formation and relate mining in accordance with geological characteristics.
CO3.	To build ideas on geomorphological features and land use pattern.
CO4.	Describe hydrological phenomena and dynamics of ground water movement with special mention of heavy metals, rainwater harvesting and watershed management.
CO5.	Utilize the concept of remote sensing systems, types, characteristics and applications of sensors and determine geological and geographical mapping using GIS.

Course Description: This course focuses the interactions between the geology, biology, chemistry and physics of the Earth's surface, oceans and atmosphere. It gives a deep understanding of the Earth's environment and how it can be influenced by human activities.
The course provides a firm grounding in environmental geosciences, building knowledge to the fields of geochemistry, hydrology, remote sensing and GIS. Moreover relevant environmental management issues like rainwater harvesting and watershed management are another aspect of the course. This course equips students with the skills needed to tackle pressing environmental challenges from climate change to contaminated groundwater to geohazards, leading to an exciting career as geoscientist or another environmental path.

Detailed syllabus

Unit I: The earth (10L)

The Earth and other planets; Fundamental concept of environmental geosciences; Geological Time Scale and major changes on the Earth's surface; Supercontinents; Space and time scales of processes in the solid Earth; Evolution, structure and composition of lithosphere; Basic principles of stratigraphy; Fossil records; Mass extinctions; Earth's gravity and magnetic fields and its thermal structure: Geoid, spheroid; Isostasy; Earth's geodynamic processes: Elemental ideas of folds, faults, joints, foliation, lineation, cleavage and schitosity; Physicochemical and seismic properties of Earth's interior, Palaeomagnetism; Polar wandering; Continental drift, sea floor spreading, plate tectonics and mountain building processes.; Concept of geodynamo; Palaeoclimate.

Unit II: Rocks and minerals (5L)

Gross composition, physical properties and distribution of important minerals and rocks; Processes responsible for mineral concentrations; Different Rock types – igneous, metamorphic and sedimentary; Rock cycle; Weathering of rocks - physical, chemical and biological; Erosion, Transportation and deposition of earth's materials by running water, wind and glaciers; Mineral deposits: Formation and classification; Environmental problems associated with extraction of mineral deposits; Geological characteristics in relation to mining; Impact of mining on environment; Acid mine drainage; Radioactive and stable isotopes.

Unit III: Physiography and Geomorphology (5L)

Development of land forms; land use pattern; Glaciers: Physical and chemical aspects; Mass balance; Recession of Himalayan glaciers; Glaciers as index of climate change; Physiographic features and river basins in India; Formation of landforms; Geophysical fields.

Unit IV: Geochemistry (5L)

Geochemical classification of elements, abundance of elements in bulk earth, crust, hydrosphere and biosphere. Partitioning of elements during surficial geologic processes, Geochemical recycling of elements. Concept of major, trace, and rare earth elements (REE); Geochemical pathways of essential elements; Intake and absorption of elements; Brief outline of medicinal uses of minerals and rocks; Geoenvironment and health; Geomedicine; Essential Elements in earth's crust, soil and plants;

Unit V: Hydrology (10L)

Hydrological characteristics of aquifer: Aquifers (unconfined, confined and semi-confined); Porosity,void ratio, permeability, transmissivity, storability, specific yield, specific retention, diffusivity, velocity;Elasticity of confined aquifer.

Laws of ground water movement: Bernoulli's equation; Darcy's Law; Laplace equation; Water flow in saturated and unsaturated soils, Poiseuille's law, permeability and fluidity, hydraulic diffusivity; measurement of hydraulic conductivity in saturated and unsaturated soils. Flow rates,steady and unsteady unidirectional flow; radial flow,Human use of surface

and ground water; Recharge and discharge areas;Safe yield and overdraft; Land subsidence; Rainwater harvesting and artificial recharge; Consumptiveand conjunctive use of water; Arsenic and fluoride contamination in sub-surface water; Watershed management

Unit VI: Geophysical Hazards (5L)

Catastrophic geological hazards; Mass movements; landslides, earthquakes, volcanism, avalanche, tsunami and Prediction of hazards and mitigation of their impacts.

Unit VII: Remote sensing and GIS (5L)

Principles of Remote Sensing; Energy sources and the electromagnetic spectrum; Energy interaction in the atmosphere; Concepts of platform and sensors, remote sensing systems, types of sensors, their characteristics and application; GIS: Historical development of GIS; Objective, components and elements of GIS; Geological and Geographical mapping; soil mapping; Land use/Land cover mapping; GIS in forestry.

Text Books

1. Mahapatra, G.B., Textbook of Physical Geology, CBS.
2. Singh, S., Physical Geography, Prayag.
3. Keller, E.A., Introduction to Environmental Geology, Pearson Education.
4. Valdiya, K.S., Geology, Environment and Society, Orient Blackswan Private Limited.
5. Schneid, T.D. & Collins, L. 2001. Disaster Management and Preparedness. LewisPublishers, New York, NY.
6. Smith, K. 2001. Environmental Hazards: Assessing Risk and Reducing Disaster. RoutledgePress.
7. Remote sensing and GIS (2nd Edition) Basudev Bhatta, Oxford University Press
8. Sabins, F.F. 1996. Remote Sensing: Principles an Interpretation. W.R. Freeman

Reference books

1. Valdiya, K.S., Environmental Geology: Ecology, Resource and Hazard Management, McGraw Hill Education.
2. Kehew, A.E., Geology for Engineers and Environmental Scientists, Pearson Education.
3. Husain, M., Fundamentals of Physical Geography, Rawat Publications.
4. Montgomery, C.W., Environmental Geology, McGraw Hill Education.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Environmental Geosciences	**Course Code : SEN51106**	
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO 1	Understand the geodynamic processes physicochemical and seismic properties of Earth, various catastrophic geophysical hazards and their impacts..	**PO2, PO4, PO5, PO8, PSO1, PSO4**
CO 2	Classify different types of rocks and minerals, rock cycle and formation and relate mining in accordance with geological characteristics.	**PO1, PO2, PO3, PO4, PO5, PO6, PO7, PSO1, PSO3, PSO4**
CO 3	To build ideas on geomorphological features and land use pattern.	**PO1, PO2, PO4, PO8, PSO1, PSO2, PSO4**
CO 4	Describe hydrological phenomena and dynamics of ground water movement with special mention of heavy metals, rainwater harvesting and watershed management.	**PO2, PO4, PO6, PO7, PO8, PSO1, PSO4**
CO 5	Utilize the concept of remote sensing systems, types, characteristics and applications of sensors and determine geological and geographical mapping using GIS.	**PO2, PO4, PO5, PO6, PO7, PSO3, PSO5**

		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource management, and loss of biodiversity.	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental issues.	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
SEN51106	**Environmental Geosciences**	2	3	3	3	3	3	3	3	3	2	2	3	3	2

1 = weakly mapped

2 = moderately mapped

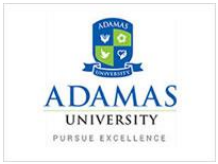
3 = strongly mapped

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	Internal	Attendance	Mid Term	End Term
Weightage (%)	30	10	20	40

Model Question Paper

Name: **Enrolment No:**	

Course: SEN51106 – Environmental Geosciences

Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**

Semester: Odd 2020-21 **Max. Marks: 40**

Total no. of questions: 12

Instructions:

Attempt all (five) questions from **Section A** (each carrying 2 marks); any **Four Questions** from **Section B** (each carrying 5 marks); any one question from **Section C** (carrying 10 marks)**.**

Section A (Attempt **all the questions)**			
1.	What does the GRACE satellite measure?	**U**	**CO1**
2.	What is a water table aquifer?	**R**	**CO3**
3.	What is Darcy's Law	**R**	**CO5**
4.	What is SAR?	**Ap**	**CO2**
5.	What is the oil window?	**U**	**CO4**
Section B (Attempt any **four questions)**			
6.	Write a short note on acid mine drainage.	**An**	**CO4**
7.	Write out with a diagram the hydrological cycle.	**U**	**CO3**
8.	What are the layers of the Earth and their approximate depths (thicknesses)?	**R**	**CO1**
9.	What is remote sensing? What are the types of remote sensing? (2+3=5)	**U**	**CO2**
10.	What are the components of rainwater harvesting?	**U**	**CO5**
Section C (Attempt any **one question)**			
11.	What tectonic settings are of most concern from the perspective of geologic hazard, and why?	**E**	**CO3**
12.	What is the role of watershed management in ground water recycling?	**An**	**CO4**

SEN51108	Environmental Instrumentation	L	T	P	C
Version 1.0	**Contact Hours – 30**	2	0	0	2
Pre-requisites/Exposure	Basic physics, chemistry and mathematics.				
Co-requisites	-				

Course Objectives

1. To utilize the fundamental concept of spectroanalytical methods.
2. To illustrate the basic principles of quantitative analysis through instrumentations.
3. To detect and analyse environmental samples using spectrometric instruments.
4. To classify various separation techniques.
5. To analyze samples using chromatographic methods.

Course Outcomes

On completion of this course, the students will be able to

CO1.	Develop the concept of spectroanalytical methods using fundamental laws of spectroscopy.
CO2.	Demonstrate the basic principles of quantitative analysis and instruments.
CO3.	Analyze environmental samples using various spectroscopic instruments.
CO4.	Classify different separation techniques using solvent extraction methods.
CO5.	Analyze samples both qualitatively and quantitatively using advanced chromatographic methods and instruments.

Course Description: Environmental Chemistry depends heavily on reliable techniques which can meet the challenging problems of environmental chemical analysis. For example, public health analysts are required to monitor trace metals such as copper, cadmium, lead, zinc, chromium, nickel, mercury and molybdenum in drinking water supplies in parts per million, ppb range (10^{-8}-10^{-10}). Most analytical techniques are common to water, air, soil and biological samples. This course covers the more important instrumental techniques. This has become inevitable because most of these instrumental techniques are common to several environmental samples analysis. However, it must be kept in mind that they are still a number of challenging problems in developing and utilising techniques for environmental chemical analysis. The course focuses the use of sensitive instrumental techniques used for environmental monitoring along with the techniques for trace analysis using sophisticated instruments light X-Ray Diffraction (XRD), X-Ray Fluorescence Spectroscopy (XRF), High Performance Liquid Chromatograph (HPLC) etc.

Detailed syllabus

Unit I: Spectroanalytical methods (17L)

Concepts of spectra; fundamental laws of spectroscopy, validity of Beer-Lambert's law. UV-Visible Spectrometry: Basic principles of instrumentation (light source,monochromator and

detector) for single and double beam instrument; Basic principles of quantitative analysis; Estimation of metal ions from aqueous solution, geometrical isomers; Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method; Infrared Spectrometry: Basic principles of instrumentation (radiation source,monochromator and detector) for single and double beam instrument; Concept of isotope substitution; Fundamental concepts of Atomic Absorption and Emission Spectrometry; Flame photometry; Atomic absorption spectrometry; Fluorimetry; Basic principles ofinstrumentation(choice of source, monochromator, detector, choice of flame and Burnerdesigns. Techniques of atomization and sample introduction; Method of backgroundcorrection, sources of chemical interferences and their method of removal. Techniquesfor the quantitative estimation of trace level of metal ions from water samples, X-Ray Diffraction studies; X-Ray Fluorescence Spectroscopy.

Unit II: Separation techniques (Solvent extraction and chromatography) (13L)

Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions. Extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media. Chromatography; principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Chromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects of chromatographic methods of analysis: IC, GLC, GPC, TLC and HPLC.Stereoisomeric separation and analysis: Measurement of optical rotation, calculation ofEnantiomeric excess (ee)/ diastereomeric excess (de) ratios and determination ofenantiomeric composition using NMR, Chiral solvents and chiral shift reagents. Chiralchromatographic techniques using chiral columns (GC and HPLC).

Text Books

1. Vogel, A.I., Textbook of quantitative chemical analysis, Pearson Education
2. Khopkar, S.M., Basic knowledge of analytical chemistry, New Age International Private Limited.
3. Christian, G.D., Dasgupta, P.K., and Schug, K.A., Analytical Chemistry, Wiley.
4. Srivastava, B.B.L, and Mishra, A, Fundamentals of Analytical Chemistry, IP Innovative Publication Pvt. Ltd.

Reference books

1. Skoog, D., West, D., Holler, F.J., and Crouch. F., Analytical Chemistry : An Introduction, Brooks/Cole.
2. Khopkar, S.M., Analytical Chemistry: Problems and Solutions, New Age International Private Limited.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Environmental Instrumentation Course Code : SEN51108		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO 1	Develop the concept of spectroanalytical methods using fundamental laws of spectroscopy.	**PO3, PO6, PO7, PO8, PO9, PSO1, PSO4**
CO 2	Demonstrate the basic principles of quantitative analysis and instruments.	**PO2, PO4, PO7, PO8, PSO1, PSO2, PSO4**
CO 3	Analyze environmental samples using various spectroscopic instruments.	**PO3, PO6, PO7, PO8, PO9, PSO1, PSO5**
CO 4	Classify different separation techniques using solvent extraction methods.	**PO2, PO4, PO7, PO8, PSO1, PSO2, PSO4**
CO 5	Analyze samples both qualitatively and quantitatively using advanced chromatographic methods and instruments.	**PO3, PO6, PO7, PO8, PO9, PSO1, PSO5**

		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource management, and loss of biodiversity.	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental issues.	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
SEN51108	**Environmental Instrumentation**	3	3	3	3	2	3	3	3	3	2	2	3	3	2

1 = weakly mapped

2 = moderately mapped

3 = strongly mapped

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	Internal	Attendance	Mid Term	End Term
Weightage (%)	30	10	20	40

Model Question Paper

Name: **Enrolment No:**	ADAMAS UNIVERSITY PURSUE EXCELLENCE

Course: SEN51108 – Environmental Instrumentation

Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**
Semester: Odd 2020-21 **Max. Marks: 40**
Total no. of questions: 12

Instructions:
Attempt all (five) questions from **Section A** (each carrying 2 marks); any **Four Questions** from **Section B** (each carrying 5 marks); any one question from **Section C** (carrying 10 marks)**.**

Section A (Attempt **all the questions)**

1.	Differentiate between EDL and HCL.	**U**	**CO2**
2.	What is Lambert – Beer's Law?	**R**	**CO1**
3.	What do you mean by cold vapour techniques?	**An**	**CO3**
4.	What do you mean by Thin Layer Chromatography?	**Ap**	**CO4**
5.	What is Ion Chromatography?	**U**	**CO4**
6.	Write down the working principle of HPLC.	**R**	**CO4**
7.	Briefly explain the working principle and different parts of flame photometer.	**U**	**CO2**
8.	Differentiate between Gas Chromatography and Liquid Chromatography.	**An**	**CO4**
9.	Write down the working principle of X-ray Diffraction.	**Ap**	**CO2**
10.	How does Arsenic (As) is determined using FIAS?	**E**	**CO3**
11.	Briefly explain the estimation of lead (Pb) of a water sample using graphite tube furnace.	**C**	**CO3**
12.	Briefly explain the working principle of Chromatography and different types of Chromatography.	**U**	**CO4**

SEN51202	Environmental Monitoring Laboratory	L	T	P	C
Version 1.0	Contact Hours – 120	0	0	8	4
Pre-requisites/Exposure	Basic physics, chemistry, biology and mathematics.				
Co-requisites	-				

Course Objectives

1. To enable the student to function as a member of an interdisciplinary pollution monitoring team.
2. To understand the fundamental principles behind different analytical procedures.
3. To enable the students to design and carry out instrumental techniques as well as accurately record and analyse the results of such experiments
4. To help the students appreciate the central role of pollution monitoring in our society and use this as a basis for ethical behaviour in issues facing environmental scientists including an understanding of safe handling of chemicals, environmental issues and key issues facing our society in energy, health and medicine..

Course Outcomes

On completion of this course, the students will be able to

CO1.	Explore new areas of research in both analytical chemistry and allied fields of science and technology.
CO2.	Illustrate expertise in pollution monitoring.
CO3.	Categorize different types of instrumental procedures.
CO4.	Understand the importance of multidisciplinary approach for interdisciplinary problems.
CO5.	Use data collection and analysis tools to develop plans for managing resource and environmental challenges and adapt plans in response to rapid change.

Course Description:

In this course students will learn basic monitoring techniques for environmental pollution. Students will also learn to utilize electronic data acquisition systems and further develop their scientific writing skills.

List of Experiments:

1. Measurement of pH and conductivity of water.
2. Measurement of turbidity and colour of water.
3. Determination of Chemical Oxygen Demand (COD).
4. Determination of Biological Oxygen Demand (BOD).
5. To select and quantify a treatment program for removal of suspended solids (Jar test).
6. Estimation of soil moisture, soil pH and soil electrical conductivity.
7. Titrimetric estimation of organic carbon in soil.
8. Determination of soil carbonate and bicarbonate.
9. Estimation of Ca, Mg and P in soil.
10. Determination of free acidity in ammonium sulphate fertilizer.
11. Estimation of Ca in Calcium ammonium nitrate fertilizer.

12. Estimation of phosphoric acid in superphosphate fertilizer.

Reference Books:

1. Vogel's Text Book of Practical Organic Chemistry (5th Edition)
2. A Handbook of Organic Analysis: Qualitative and Quantitative (4th Edition) -Clarke
3. Standard Methods for the Examination of Water, American Public Health Association, American Water Works Association, Water Environment Federation

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Environmental Monitoring Laboratory		**Course Code : SEN51202**
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO 1	Explore new areas of research in both analytical chemistry and allied fields of science and technology.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 2	Illustrate expertise in pollution monitoring.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 3	Categorize different types of instrumental procedures.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 4	Understand the importance of multidisciplinary approach for interdisciplinary problems.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 5	Use data collection and analysis tools to develop plans for managing resource and environmental challenges and adapt plans in response to rapid change.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	**Mid Term**	**Attendance**	**Class Assessment**	**End Term**
Weightage (%)	**20**	**10**	**30**	**40**

		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource management, and loss of biodiversity.	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental issues.	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
SEN51202	**Environmental Monitoring Laboratory**	2	2	2	2	-	2	3	3	3	3	2	2	3	-

1 = weakly mapped

2 = moderately mapped

3 = strongly mapped

Model Question Paper

Name: **Enrolment No:**	

Course: SEN51202 – Environmental Monitoring Laboratory

Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**
Semester: Odd 2020-21 **Max. Marks: 40**
Total no. of questions:

Instructions:
Attempt all questions**.**

Section A (Attempt **all the questions)**

1.	Estimate the COD of the water sample supplied.	An	CO2
2.	VIVA		

SEN51204	Environmental Instrumentation Lab	L	T	P	C
Version 1.0	**Contact Hours – 60**	0	0	4	2
Pre-requisites/Exposure	Basic physics, chemistry, biology and mathematics.				
Co-requisites	-				

Course Objectives

1. To enable the student to function as a member of an interdisciplinary environmental monitoring team.
2. To understand the fundamental principles behind different instrumental techniques.
3. To enable the students to design and carry out instrumental techniques as well as accurately record and analyse the results of such experiments
4. To help the students appreciate the central role of monitoring of environmental health in our society and use this as a basis for ethical behaviour in issues facing environmental scientists.

Course Outcomes

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

CO1.	Explore new areas of research in both analytical chemistry and allied fields of science and technology.
CO2.	Illustrate expertise in pollution monitoring.
CO3.	Categorize different types of instrumental procedures.
CO4.	Understand the importance of multidisciplinary approach for interdisciplinary problems.
CO5.	Use data collection and analysis tools to develop plans for managing resource and environmental challenges and adapt plans in response to rapid change.

Course Description:

In this course students will learn basic instrumental techniques for monitoring environmental health. Students will also learn to utilize electronic data acquisition systems and further develop their scientific writing skills.

List of Experiments:

1. Gravimetric estimation of TSS, TDS in water.
2. Gravimetric estimation of oil and grease present in water.
3. Gravimetric estimation of chloride in water.
4. Determination of pK_a values of indicator using spectrophotometry.
5. Colourimetric estimation of iron in water.
6. Spectrophotometric analysis of $SO_4^{2-}$and PO_4^{3-} in water.
7. Spectrophotometric analysis of NO_3^{2-} in water.
8. Sampling of air using High Volume Sampler/Respirable Dust Sampler
9. Analysis of SOx and NOx in air.
10. Analysis of Pb in water and soil using atomic absorption spectrophotometer.
11. Analysis of F^-, CN^- and NH_3 in water using ion selective electrode.

Reference Books:

1. Vogel's Text Book of Practical Organic Chemistry (5th Edition)
2. A Handbook of Organic Analysis: Qualitative and Quantitative (4th Edition) -Clarke
3. Standard Methods for the Examination of Water, American Public Health Association, American Water Works Association, Water Environment Federation

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Environmental Instrumentation Lab		**Course Code : SEN51204**
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO 1	Explore new areas of research in both analytical chemistry and allied fields of science and technology.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 2	Illustrate expertise in pollution monitoring.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 3	Categorize different types of instrumental procedures.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 4	Understand the importance of multidisciplinary approach for interdisciplinary problems.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 5	Use data collection and analysis tools to develop plans for managing resource and environmental challenges and adapt plans in response to rapid change.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	**Mid Term**	**Attendance**	**Class Assessment**	**End Term**
Weightage (%)	**20**	**10**	**30**	**40**

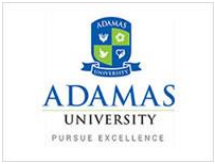
		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource management, and loss of biodiversity.	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental issues.	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
SEN51204	**Environmental Instrumentation Lab**	2	2	2	2	-	2	3	3	3	3	2	2	3	-

1 = weakly mapped

2 = moderately mapped

3 = strongly mapped

Model Question Paper

Name: **Enrolment No:**	

Course: SEN51204 – Environmental Instrumentation Lab

Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**
Semester: Odd 2020-21 **Max. Marks: 40**
Total no. of questions:

Instructions:
Attempt all questions**.**

Section A (Attempt **all the questions)**

1.	What is the principle behind working of ISE for fluoride and cyanide analysis? What is the role of buffer?	An	CO2
2.	Measure the concentration of fluoride and cyanide in the given samples?	C	CO5
3.	What is the principle behind spectrophotometric estimation of NO_3^- in water.	U	CO3

SEN51206	Environmental Geoscience Lab	L	T	P	C
Version 1.0	**Contact Hours – 90**	0	0	6	3
Pre-requisites/Exposure	Basic physics, chemistry, biology and mathematics.				
Co-requisites	-				

Course Objectives

1. To enable the student, understand the wide diversity of contamination and remediation problems and the significance of geology in many situations.
2. To explain the the principles and framework of contaminated land investigation, remediation and redevelopment.
3. To enable the students to design and carry out various techniques as well as accurately record and analyse the results of such experiments
4. To help the students appreciate the central role of the types, advantages and limitations of the principal methods of sampling, geophysical and invasive ground investigation techniques

Course Outcomes

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

CO1.	Apply advanced geological and geotechnical principles to the solution of a complex problem.
CO2.	Develop and manage an Environmental Geoscience research project from hypothesis building to result interpretation.
CO3.	Develop their own fieldwork program.
CO4.	Undertake computer analyses and modelling with industry-standard software.
CO5.	Describe the major sources of water, soil, and sediment pollution and methods for their management.

Course Description:

This course provides students with excellent opportunities to develop key skills in applied geology with a specialist knowledge of specific aspects of applied geosciences, such as environmental pollution, site and ground investigation techniques, computer applications in environmental geology including risk analysis and assessment, contaminated land, soil mechanics and hydrogeology. The course provides a challenging and stimulating environment using a mixture of class, laboratory, practical and field based teaching with a focus on vocational and transferable skills to maximise student's career opportunities.

List of Experiments:

1. Study of rocks, fossils and geological structures.
2. Study of major geomorphic features and their relationships with outcrops through physiographic models.
3. Detailed study of topographic sheets and preparation of physiographic description of an area
4. Types of geochemical data analysis and interpretation; of common geochemical plots.
5. Geochemical analysis of geological materials.
6. Study of soil profile of any specific area
7. Study of distribution of major lithostratigraphic units on the map of India

8. Study of distribution of major dams on map of India and their impact on river systems
9. Study of major ocean currents of the World
10. Study of seismic profile of a specific area and its interpretation.
11. Study of geological map of India and identification of major stratigraphic units.
12. Preparation and interpretation of water level contour maps and depth/water level maps
13. Study, preparation and analysis of hydrographs for differing groundwater conditions Water potential zones of India (map study).
14. Preparation of maps: Distribution of important ores and other economic minerals in India. Study of distribution of major climatic regimes of India on map
15. Distribution of major wind patterns on World map

Reference Books:

1. Dixon, D., The Practical Geologist: The Introductory Guide to the Basics of Geology and to Collecting and Identifying Rocks, Touchstone.
2. Philips, J., Manual of Geology: Practical and Theoretical, Nabu Press.
3. Hencher, S., Practical Engineering Geology, Taylor & Francis.
4. Lindholm, R., A Practical Approach to Sedimentology, Springer.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Environmental Geoscience Lab		**Course Code : SEN51206**
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO 1	Apply advanced geological and geotechnical principles to the solution of a complex problem.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 2	Develop and manage an Environmental Geoscience research project from hypothesis building to result interpretation.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 3	Develop their own fieldwork program.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 4	Undertake computer analyses and modelling with industry-standard software.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 5	Describe the major sources of water, soil, and sediment pollution and methods for their management.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	Mid Term	Attendance	Class Assessment	End Term
Weightage (%)	20	10	30	40

		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource management, and loss of	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental issues.	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
SEN51206	**Environmental Geoscience Lab**	2	2	2	2	-	2	3	3	3	3	2	2	3	-

1 = weakly mapped
2 = moderately mapped
3 = strongly mapped

Model Question Paper

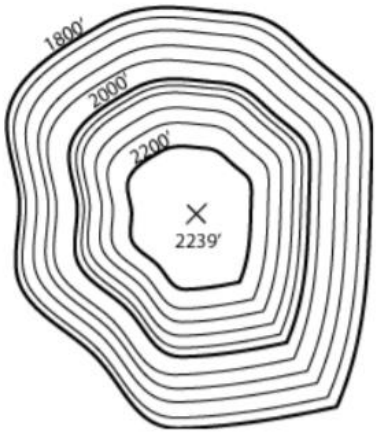
Name: **Enrolment No:**	ADAMAS UNIVERSITY PURSUE EXCELLENCE

Course: SEN51206 – Environmental Geoscience Lab

Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**
Semester: Odd 2020-21 **Max. Marks: 40**
Total no. of questions:

Instructions:
Attempt all questions**.**

Section A (Attempt **all the questions)**

1.	Identify the rock samples provided.	An	CO2
2.	List and discuss anthropogenic vs. natural environmental geology problems.	R	CO5
3.	What kind of topographic landform is represented in the following illustration?  	Ev	CO3
4.	For the illustration in question 3 what are the bold contours called?	Ev	CO3
5.	For the illustration in question 3 what is the contour interval?	An	CO3

SEN51702	Industry Internship	L	T	P	C
Version 1.0	Contact Hours – 60	x	x	x	2
Pre-requisites/Exposure	-				
Co-requisites	-				

Course Objectives

1. Higher order of communication skills. (i.e. speaking, writing, presenting, persuasion (sales), customer service,interpersonal, teamwork, leadership, and listening — as practiced in the professional world.)
2. Develop professional behaviour and/or knowledge. (i.e. learn employer expectations for workplace behaviours; gain knowledge of a specific company/industry; learn specific common job functions.
3. Improved Computer/technology skills. (i.e. improve skills with specific hardware/software/applications or social media; understand how certain technologies are used in specific industries/companies; achieve certification in a specific technical area.)
4. Develop specific skill-building. (i.e. Improve skills, confidence, competency in specific areas related to the student's particular area of career interest.)
5. Inculcate project-related skills. (i.e. develop skills in research, analysis, organization, time management, teamwork, multiple task coordination, initiative, adaptability, and project completion.)
6. Employability-enhancing activities for the students.

Course Outcomes

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

CO1.	Solve problems typically encountered by professionals in industry.
CO2.	Identify and address social, economic, and safety issues in any problem and develop a solution that addresses this
CO3.	Learn new concepts and apply them to the solution of environmental problems.
CO4.	Function effectively on a multidisciplinary team.
CO5.	Interface effectively with other areas of the organization
CO6.	Demonstrate communication skills by expressing their ideas orally and in writing.
CO7.	Illustrate preparedness for a lifelong productive career.

Course Description: An internship experience in a relevant industry will provide an excellent opportunity to explore future career interests while applying knowledge and skills learned in the classroom in a work setting.

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	Internal	Presentation Oral	Presentation Notebook	Understanding of the problem	Methodology for Field Investigation	Content	Analysis	Conclusion
Weightage (%)	**20**	**15**	**15**	**10**	**10**	**10**	**10**	**10**

Modes of Evaluation: Quiz/Assignment/Presentation/Extempore/Written Examination
Examination Scheme:

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO1	Solve problems typically encountered by professionals in industry.	**PO4, PO6, PO9, PSO1**
CO2	Identify and address social, economic, and safety issues in any problem and develop a solution that addresses this	**PO4, PO5, PO6, PO7, PO9, PSO3**
CO3	Learn new concepts and apply them to the solution of environmental problems.	**PO3, PO4, PO5, PO6, PO7, PO8, PO9, PSO3, PSO4**
CO 4	Function effectively on a multidisciplinary team.	**PO4, PO6, PO9, PSO1**
CO 5	Interface effectively with other areas of the organization	**PO4, PO5, PO6, PO7, PO9, PSO3**
CO 6	Demonstrate communication skills by expressing their ideas orally and in writing.	**PO3, PO4, PO5, PO6, PO7, PO8, PO9, PSO3, PSO4**
CO 7	Illustrate preparedness for a lifelong productive career.	**PO4, PO6, PO9, PSO1**

		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource management, and loss of biodiversity.	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental issues.	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
SEN51702	**Industry Internship**	2	3	3	3	3	2	3	3	3	2	2	2	3	1

1 = weakly mapped

2 = moderately mapped

3 = strongly mapped

SEN52101	Statistical applications in Environmental Systems	L	T	P	C
Version 1.0	**Contact Hours – 60**	4	0	0	4
Pre-requisites/Exposure	Basic physics, chemistry, and mathematics.				
Co-requisites	-				

Course Objectives

1. To introduce basic concepts useful for environmental data analysis
2. To develop an intuitive statistical sense for inferring meaning out of data collected from different environmental matrices
3. To extract information and draw scientific inference from large amount of data collected to solve environmental problems
4. To analyse trend and seasonality in environmental data and apply statistical tools and software to analyse environmental data

Course Outcomes

On completion of this course, the students will be able to

CO1.	Apply statistics for environmental monitoring and sampling by using specific R packages
CO2.	Apply discrete and continuous probability distributions to environmental data
CO3.	Demonstrate Test of Hypothesis and calculate confidence interval for a population parameter for single sample and two sample cases and understand concept of p-values.
CO4.	Describe non-parametric test such as, the Chi-Square test for Independence and Goodness of Fit.
CO5.	Assess and interpret the results of Bivariate and Multivariate Regression and Correlation Analysis, ANOVA and F-test.

Course Description: This course is an introduction to statistical methods for environmental data analysis. Topics include sampling, capture-recapture methods, regression, toxicology, risk analysis, time series, spatial statistics, and environmental extremes. This course provides students with an understanding of basic statistical concepts critical to the proper use and understanding of statistics in environmental conservation. Topics included are measures of central tendency and dispersion, probability distributions, the Central Limit Theorem, Sampling, Estimation, Hypothesis testing, Analysis of Variance, Correlation and Regression analysis, Multiple Regression and Statistical Forecasting.

Detailed syllabus

Unit I: Overview of statistics and probability **(15L)**

Statistics in the context of environmental analysis; Probability concepts and probability distributions; conditional probability and Bayes' theorem.

Unit II: Data analysis **(15L)**

Fundamentals of data analysis; Measurement uncertainty: Precision and accuracy; Reproducibility/repeatability; Types of Error, Normal error curve; Error propagation; Quality assurance and quality control; Confidence intervals.

Unit III: Estimation and test of significance **(10L)**

Hypothesis testing for equality of mean and standard deviation: t-test, chi-square test and F-test; Errors in hypothesis testing.

Unit IV: Analysis of variance **(10L)**

Experiment design and analysis of variance; ANOVA concepts; Completely randomized design; Randomized block design; Two-way factorial design; Variance component analysis; Factorial and fractional factorial design; Significance of interaction between factors.

Unit V: Correlation and regression **(10L)**

Regression versus correlation; Autocorrelation in data; Linear versus non-linear regression models; Linear least-squares regression; Precision of parameter estimates, coefficient of determination: inherent limitations; Non-parametric statistics; Exercises using the statistical package SYSTAT.

Text Books

1. Ayyub, B.M. and McCuen, R.H. (2011) Probability, Statistics and Reliability for Engineers and Scientists, CRC Press, Boca Raton, FL.
2. Gilbert R.O. (1987) Statistical Methods for Environmental Pollution Monitoring, New York, Van Nostrand Reinhold.
3. Helsel D.R. and Hirsch R.M. (1997) Statistical Methods in Water Resources, Elsevier Science Ltd., UK.
4. Kottegoda N.T. and Rosso R. (2008) Applied Statistics for Civil and Environmental Engineers, McGraw-Hill, International Edition.

Reference books

1. Berthouex P.M. and Brown L.C. (1994) Statistics for Environmental Engineers, Lewis Publishers, CRC Press, Boca Raton, FL.
2. Cothern C.R. and Ross N.P. (1994) Environmental Statistics, Assessment and Forecasting, Lewis Publishers, Boca Raton, FL.
3. Hoshmand A.R. (1997) Statistical Methods for Environmental and Agricultural Sciences, CRC Press, Boca Raton, FL.

4. Gibbons R.D. (1994) Statistical Methods for Groundwater Monitoring, John Wiley & Sons, New York.
5. Ginevan M.E., Splistone D.E. (2004) Statistical Tools for Environmental Quality Measurement. John Wiley & Sons Hoboken, NJ.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Statistical applications in Environmental Systems		**Course Code : SEN52101**
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO1	Apply statistics for environmental monitoring and sampling by using specific R packages	**PO1, PO2, PO5, PO6, PO7, PO8, PSO1, PSO2, PSO4**
CO2	Apply discrete and continuous probability distributions to environmental data	**PO1, PO2, PO7, PO8, PO9, PSO2, PSO3, PSO4**
CO3	Demonstrate Test of Hypothesis and calculate confidence interval for a population parameter for single sample and two sample cases and understand concept of p-values.	**PO2, PO6, PO7, PO8, PSO2, PSO3, PSO5**
CO4	Describe non-parametric test such as, the Chi-Square test for Independence and Goodness of Fit.	**PO2, PO3, PO5, PO6, PO7,PO8,PSO2, PSO4**
CO5	Assess and interpret the results of Bivariate and Multivariate Regression and Correlation Analysis, ANOVA and F-test.	**PO1, PO2, PO3, PO4, PO8, PO9, PSO2, PSO3, PSO5**

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	**Internal**	**Attendance**	**Mid Term**	**End Term**
Weightage (%)	**30**	**10**	**20**	**40**

		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource management, and loss of biodiversity.	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental issues.	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO 1	PO 2	PO3	PO4	PO 5	PO6	PO 7	PO 8	PO 9	PSO 1	PSO 2	PSO3	PSO4	PSO5
SEN52101	**Statistical Applications in Environmental Systems**	2	3	3	3	2	3	3	3	2	3	3	2	2	2

1 = weakly mapped

2 = moderately mapped

3 = strongly mapped

Model Question Paper

Name: **Enrolment No:**	

Course: SEN52101 – Statistical applications in Environmental Systems

Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**

Semester: Odd 2020-21 **Max. Marks: 40**

Total no. of questions: 12

Instructions:

Attempt all (five) questions from **Section A** (each carrying 2 marks); any **Four Questions** from **Section B** (each carrying 5 marks); any one question from **Section C** (carrying 10 marks)**.**

Section A (Attempt **all the questions)**			
1.	For any finite set of positive numbers state the correct relationship involving harmonic mean, geometric mean and arithmetic mean.	**R**	**CO1**
2.	A container has 3 white balls and two black balls identical in size. The balls are drawn without replacement. What is the probability that the balls are of two different colours?	**C**	**CO4**
3.	Which statistical device helps in analysing the co-variation of two or more variables?	**U**	**CO5**
4.	How many ways the eight tigers in a cage be fed with three small wild animals, three small goats and two domestic fowls?	**C**	**CO3**
5.	In a bar graph, the bars are drawn in decrease order of frequency – what type of bar graph is this?	**E**	**CO1**
Section B (Attempt any **four questions)**			
6.	Define mean, median, mode of a frequency distribution and discuss their advantages and limitations.	**U**	**CO3**
7.	Based on random assessment for four years, the mean net production and standard deviation for grassland 120 gC/m^2/year and 4 gC/m^2/year respectively. Calculate the 90% and 95% confidence interval around this estimate.	**C**	**CO5**
8.	Two groups of five vehicles each running on diesel and petrol respectively produce 6.4 kg and 5 kg emissions per day given the population standard deviation is 4 and $t_{0.05} = 2.306$. Test whether emissions of petrol and diesel vehicles differ significantly.	**C**	**CO2**
9.	What is the appropriate testing method for the condition where the variance is an unknown parameter of a population of independent observations?	**U**	**CO1**
10.	In a city, daily per capita inhalation (m^3)values of contaminated air over a period of five days are 6.3, 6.2, 6.3, 6.4 and 5.8 respectively. Calculate the sample mean and standard deviation.	**An**	**CO1 , CO4**
Section C (Attempt any **one question)**			
11	a) Define linear regression and describe the method of fitting of regression line of y on x axis. b) What do you understand by the term the "level of significance"? Explain its significance with critical region	**U**	**CO3**

<table>
<tr><td></td><td>c) Calculate the mean and coefficient of variation for the following frequency distribution:

<table><tr><td>Class interval</td><td>Frequency</td><td>Class interval</td><td>Frequency</td></tr><tr><td>0-10</td><td>03</td><td>50-60</td><td>26</td></tr><tr><td>10-20</td><td>08</td><td>60-70</td><td>13</td></tr><tr><td>20-30</td><td>17</td><td>70-80</td><td>09</td></tr><tr><td>30-40</td><td>29</td><td>80-90</td><td>06</td></tr><tr><td>40-50</td><td>45</td><td>90-100</td><td>04</td></tr></table></td><td></td><td></td></tr>
<tr><td></td><td>Write notes on (i) histogram, (ii) type I and type II error and (iii) skewness and Kurtosis. Describe F test as applied in two way analysis of variance. Explain the chi square test for goodness of fit.</td><td>E</td><td>CO4</td></tr>
</table>

SEN52103	Solid and Hazardous Waste Management	L	T	P	C
Version 1.0	Contact Hours – 60	4	0	0	4
Pre-requisites/Exposure	Basic physics, chemistry, and mathematics.				
Co-requisites	-				

Course Objectives

1. Understanding of problems of municipal waste, biomedical waste, hazardous waste, e-waste, industrial waste etc.
2. Knowledge of legal, institutional and financial aspects of management of solid wastes.
3. Become aware of environment and health impacts solid waste mismanagement
4. Understand engineering, financial and technical options for waste management.

Course Outcomes

On completion of this course, the students will be able to

CO1.	Define and characterize solid and hazardous wastes from technical and regulatory points of view.
CO2.	Identify current statutory and regulatory cradle to grave framework related to hazardous waste management.
CO3.	Understand how quantitative risk assessments are conducted for toxic substances and their adverse effects on living organisms and the environment, and the limitations of the results of these analyses.
CO4.	Interpret radiation pollution with handling and disposal of radioactive wastes.
CO5.	Identify the most common techniques for preventing, minimizing, recycling, disposing and treatment of waste and their application on site remediation.

Course Description: The course would cover-general introduction including definition of solid wastes–municipal waste, biomedical waste, hazardous waste, e-waste; legal issues and requirements for solid waste management; sampling and characterization of solid waste; analysis of hazardous waste constituents including QA/QC issues; health and environmental issues related to solid waste management; steps in solid waste management-waste reduction at source, collection techniques, materials and resource recovery/recycling, transport, optimization of solid waste transport, treatment and disposal techniques (composting, vermi-composting, incineration, non-incineration thermal techniques, refuse derived fuels, land-filling); economics of the onsite vs. offsite waste management options (individual vs. common treatment/disposal practices, integrated waste management; and waste minimization and concepts of industrial symbiosis and industrial ecology. Solid and hazardous waste are defined. Technology, health, and policy issues associated with solid waste and hazardous materials are examined. Methods of managing solid and hazardous waste are introduced and regulations presented where appropriate. The characteristics of hazardous and solid waste materials, health frameworks, and the distribution of contaminants in the environment are reviewed.

Detailed syllabus

Unit 1: Introduction (**7L)**

Classification of solid waste; Properties of solid wastes; Composition of municipal solid waste; Rate of generation of waste; Public health and environmental aspects; Integrated solid waste management

Unit 2: Solid Waste Generation, Collection and Transport **(12L)**

Generation: typical generation rates, estimation of solid waste quantities, factors affecting generation rates; Collection: Collection of Solid waste – collection services – collection system, equipments – time and frequency of collection – labour requirement – factors affecting collection – analysis of collection system – collection routes – preparation of master schedules. Transfer and Transport: Need for transfer operation – transfer stations – types – transport means and methods – location of transport stations - Manpower requirement – collection routes: Transfer stations – selection of location, types & design requirements, operation & maintenance

Unit 3: Processing Techniques and Resource and Energy Recovery **(15L)**

Processing techniques: mechanical volume reduction, thermal volume reduction, mechanical size reduction, components separation, drying and dewatering; Materials recovery systems; Recovery of biological conversion products: composting and anaerobic digestion; Recovery of thermal conversion products: combustion of waste material, incineration with heat recovery; Recovery of energy from conversion products

Unit 4: Disposal of Solid Waste **6L)**

Refuse disposal: incinerations, sanitary landfill: methods of operation, advantages and disadvantages of sanitary land fill, site selection, reactions accruing in completed landfills, gas and leachate movement and control; Plastic Waste; E-waste, The Municipal Solid Wastes (Management and Handling) Rules 2016, E-Waste (Management) Rules, 2016, Plastic Waste Management (Amendment) Rules, 2018

Unit 5: Hazardous Waste Management(20L)

Hazardous waste: definition, quantities of hazardous waste generated, Components of a hazardous waste management plan, Hazardous waste minimization; Disposal practices in Indian Industries – Future challenges; Need for hazardous waste management; Sources of hazardous wastes; Effects on community; Terminology and classification; Storage and collection of hazardous wastes; Problems in developing countries; Protection of public health and the environment; Nuclear wastes and e-waste Characteristics; Management of nuclear wastes; Decommissioning of Nuclear power reactors; Health and environmental effects; Biomedical and chemical wastes: Biomedical wastes types, management and handling, control of biomedical wastes; Chemical wastes: sources domestic and Industrial, need for control, treatment and disposal techniques; physical, chemical and biological processes, health and

environmental effects; The scientific landfill; The Hazardous and other Wastes (Management and Transboundary Movement) Rules 2016, The Biomedical Waste (Management and Handling) Rules, 2016,

Text Books

1. Chakrabarti, S., Treatment of Urban Solid Waste: Engineering and Integrated Management, TERI Press.
2. Cherry, P.M., Solid and Hazardous Waste Management, CBS.
3. Rao, M.N., and Sultana, R., Solid and Hazardous Waste Management, BS Publications / BSP Books.
4. Gupta, O.P., Elements of Solid Hazardous Waste and Management, Khanna Publishing.
5. Bhatia, S., Solid and Hazardous Waste Management, Atlantic Publication.

Reference books

1. Singh, J., Ramanathan, A.L., Solid Waste Management: Present and Future Challenges, Dreamtech Press.
2. Khan, I.H., and Ahsan, M., Textbook of Solid Waste Management, CBS.
3. Ramachandra, T.V., Management of Municipal Solid Waste, The Energy and Resources Institute.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Solid and Hazardous Waste Management		**Course Code : SEN52103**
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO 1	Define and characterize solid and hazardous wastes from technical and regulatory points of view.	**PO2, PO4, PO5, PO8, PO9, PSO1, PSO3, PSO4**
CO 2	Identify current statutory and regulatory cradle to grave framework related to hazardous waste management.	**PO1, PO2, PO3, PO4, PO5, PO 6, PO7, PSO1, PSO3, PSO4**
CO 3	Understand how quantitative risk assessments are conducted for toxic substances and their adverse effects on living organisms and the environment, and the limitations of the results of these analyses.	**PO1, PO2, PO4, PO6, PO7, PO8, PSO2, PSO3**
CO 4	Interpret radiation pollution with handling and disposal of radioactive wastes.	**PO1, PO2, PO4, PO6, PO7, PSO1, PSO4**
CO 5	Identify the most common techniques for preventing, minimizing, recycling, disposing and treatment of waste and their application on site remediation.	**PO2, PO4, PO5, PO7, PSO2**

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	Internal	Attendance	Mid Term	End Term
Weightage (%)	30	10	20	40

		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
SEN52103	**Solid and Hazardous Waste Management**	2	3	3	3	3	2	3	3	3	2	2	2	3	1

1 = weakly mapped

2 = moderately mapped

3 = strongly mapped

Model Question Paper

Name: **Enrolment No:**	

Course: SEN52103 – Solid and Hazardous Waste Management

Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**
Semester: Odd 2020-21 **Max. Marks: 40**
Total no. of questions: 12

Instructions:
Attempt all (five) questions from **Section A** (each carrying 2 marks); any **Four Questions** from **Section B** (each carrying 5 marks); any one question from **Section C** (carrying 10 marks)**.**

Section A (Attempt **all the questions)**			
1.	Mention any two types of plastics mentioned in Plastic Waste Management Rules, 2016?	**R**	**CO4**
2.	What is composting? Name any two species of earthworms used in Vermicomposting.	**R**	**CO3**
3.	What is Incineration?	**R**	**CO5**
4.	What are transfer stations in the context of solid waste management?	**U**	**CO3**
5.	What do you mean by moisture content of solid waste?	**U**	**CO2**
Section B (Attempt any **four questions)**			
6.	Estimate the unit solid waste generation rate for a residential area having 800 dwellings. The observation made at local transfer station for a week time revealed that the waste was carried in self -compacting trucks and flatbed trucks, whose volume is $15m^3$ and $1.25m^3$ and the density of waste is 295 kg/m^3 and $110kg/m^3$ respectively. Assume 10 self- compacting truck and 20 flatbed truck loads per week.	**An**	**CO1**
7.	Write an explanatory note on mechanical volume reduction.	**Ap**	**CO3**
8.	What is leachate? With neat sketch, discuss the control of leachate movement in sanitary landfill sites.	**E**	**CO1**
9.	Define hazardous waste. Explain the various sources of hazardous wastes.	**R**	**CO4**
10.	Enumerate the various methods of treating bio-medical waste. Explain any one.	**R**	**CO2**
Section C (Attempt any **one question)**			
11.	What is pyrolysis? With a neat sketch, explain the process of Pyrolysis.	**E**	**CO1**
12.	a. Determine the landfill area required for a population of 50000, given the following data. i) Solid waste generation: 1.5 kg/person/day ii) Compacted density of solid waste in landfill: $500kg/m^3$ iii) Average compacted depth of solid waste: 3M b. Explain the area method of landfilling technique	**Ap**	**CO5**

SEN51105	Environmental Microbiology and Biotechnology	L	T	P	C
Version 1.0	**Contact Hours – 60**	4	0	0	4
Pre-requisites/Exposure	Basic physics, chemistry, and mathematics.				
Co-requisites	-				

Course Objectives

1. To understand the fundamentals of microbiology including structure and function of microbial cell
2. To acquire extensive knowledge on various microbial environment including air, water, soil and survival of microorganisms in extreme environment
3. To explain the characteristics of various water borne and food borne pathogens, indicator microorganisms and standard test for measurement
4. To develop the basic concepts of bioremediation and its application in biodegradation of organic and metal pollutants
5. To perceive knowledge on the commercially important microorganisms and their application in metal and oil recovery, desulphurization, microbial insecticides, bio fertilizers, biohydrogen

Course Outcomes

On completion of this course, the students will be able to

CO1. Distinguish between prokaryotic and eukaryotic cells, describe the structure and function of cell organelles, metabolism and bacterial growth kinetics
CO2. Demonstrate the presence of various microorganisms in air water and soil and extreme environment, factors affecting their survival and control mechanism
CO3. Estimate microbiological quality of water, indicator microorganisms and explain water quality standard and methods of water purification
CO4. Describe the characteristics of various water and food borne pathogens and the associated diseases
CO5. Explain the concept of bioremediation and its diverse application including biodegradation of persistent organic pollutants, heavy metals removal from contaminated soil
CO6. Illustrate the basic concept and technological advancement in the processes of phytoremediation, biofilters, bioscrubbers, membrane reactors
CO7. Identify commercially important microorganisms and demonstrate application of bioprocesses for cleaner production in various industries

Course Description: This course will introduce students to the field of environmental microbiology and biotechnology. This course demonstrates the fundamentals of structure and function microbial cell, microbial habitat and the factors affecting their survival. This course is focused to give an in-depth understanding of microbial distribution, diversity, physiology, biochemistry, function and ecology along with commonly employed microbiology methods. Air, water and food borne diseases are an important part included in this course. Environmental biotechnology including bioremediation, biofertizers, biogas and biohydrogen and other application for cleaner production are discussed in details.

Detailed syllabus

Unit I: Fundamentals of Microbiology **(10L)**

Structure of prokaryotic and eukaryotic cells; classification of microorganisms; microbial metabolism; bacterial growth: measurement, kinetics and

Unit II: Microbial Environment **(15L)**

Microbiology of Air: Important airborne pathogens and airborne toxins, Bioaerosols and its control; factors affecting microbial survival in the air; extramural and intramural aeromicrobiology, Microorganisms in Aquatic Environments: Microbial habitats in the aquatic environment; Microorganisms in different aquatic environments: freshwater, brackish, marine and subterranean; pathogens and water-borne diseases; assessment of microbiological quality of water; indicator microorganisms, freshwater quality standard and purification of water for human use, Soil as a microbial environment: biotic stresses, abiotic stresses, microorganisms in surface soil and subsurface environment, Microorganisms in extreme environment

Unit III: Water and Food Borne Pathogens **(10L)**

Environmentally transmitted pathogens; bacteria – Salmonella, Escherichia Coli, Shigella, Campylobacter, Yersinia, Vibrio, Helicobacter, Legionella; Viruses- Enteric and Respiratory viruses; Parasitology- Protozoa, Nematodes, Cestodes, Trematodes, Indicator microorganisms: Total coliforms, MPN Test, MF Test, fecal coliforms and E. Coli, Bacteriophage, standard and criteria for indicator organisms

Unit IV: Bioremediation of organic pollutants and metal pollutants **(15L)**

Biodegradation: overview, contaminant structure, toxicity and biodegradability; environmental factors affecting biodegradation, biodegradation of organic pollutants-pollutant sources and types, biodegradation of simple aliphatics, aromatics, polycyclic aromatic hydrocarbons, halogenated hydrocarbons and pesticides, bioremediation- effects of addition of oxygen and other gases, nutrient, surfactant, microorganisms or DNA; in-situ and ex-situ bioremediation technologies, phytoremediation, biofilters, bioscrubbers, membrane bioreactors, Metal sources, solubility, bioavailability and speciation, metal toxicity on microbial cells, mechanisms of microbial metal resistance and detoxification, microorganisms mediated remediation of soil, sediment and aquatic systems

Unit V: Bioprocesses for cleaner production **(10L)**

Biogeotechnology- Bioleaching of metals: Characteristics of commercially important microbes, mechanisms of bioleaching, factors affecting bioleaching and current biomining processes for recovery of precious metals (biohydrometallurgy); Microbially enhanced oil recovery; Biodesulphurization of coal: Removal of organic and inorganic sulphur from coal; Microbial Insecticides: Bacterial, fungal and viral insecticides in pest management; Biofertilizers: Nitrogen fixing and phosphate solubilizing biofertilizers; Biobleaching in pulp and paper industries; Biofuel production : biohydrogen, biogas, Introduction to recombinant biotechnology and its application for enhanced biodegradation

Text Books

1. Maier, R.M., Pepper I.L., Gerba, C.P., Environmental Microbiology, Academic Press
2. Pelczar Jr., M.J., Chan, E.C.S. and Kreig, N.R., Microbiology, 5th Edition, McGraw-Hill Publishing Co. Ltd., New Delhi, 1993.
3. Brock Biology of Microorganisms, 13th Edition, Prentice Hall Publication
4. Patrick K. Jjemba., Environmental Microbiology: Principles and Applications.
5. Glazer, A.N., Nikaido, H., Microbial Technology, 2nd Edition, Cambridge University Press

Reference books

1. Bitton, G., Wastewater Microbiology, Wiley-Liss Inc., New York, 1994
2. Prescott's Microbiology, 11th Edition, McGraw Hill Publishers
3. Adams, M.R., Food Microbiology, New Age Publication
4. Pajarathinam., R., Medical Microbiology, New Age Publication
5. Kun, L.Y., Microbial Biotechnology: Principles and Applications, World Scientific Publishing Company

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Energy and Environment		**Course Code : SEN51101**
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO 1	Distinguish between prokaryotic and eukaryotic cells, describe the structure and function of cell organelles, metabolism and bacterial growth kinetics	**PO1, PO2, PO5, PO6, PO7, PO8, PSO1, PSO2, PSO4**
CO 2	Demonstrate the presence of various microorganisms in air water and soil and extreme environment, factors affecting their survival and control mechanism	**PO1, PO2, PO7, PO8, PO9, PSO2, PSO3, PSO4**
CO 3	Estimate microbiological quality of water, indicator microorganisms and explain water quality standard and methods of water purification	**PO2, PO6, PO7, PO8, PSO2, PSO3, PSO5**
CO 4	Describe the characteristics of various water and food borne pathogens and the associated diseases	**PO2, PO3, PO5, PO6, PO7,PO8,PSO2, PSO4**
CO 5	Explain the concept of bioremediation and its diverse application including biodegradation of persistent organic pollutants, heavy metals removal from contaminated soil	**PO1, PO2, PO3, PO4, PO8, PO9, PSO2, PSO3, PSO5**
CO 6	Illustrate the basic concept and technological advancement in the processes of phytoremediation, biofilters, bioscrubbers, membrane reactors	**PO2, PO5, PO8, PO9, PSO1, PSO2, PSO3, PSO4**

CO 7	Identify commercially important microorganisms and demonstrate application of bioprocesses for cleaner production in various industries	**PO2,PO3, PO5, PO8, PO9, PSO1, PSO2, PSO3, PSO5,**

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	Internal	Attendance	Mid Term	End Term
Weightage (%)	**30**	**10**	**20**	**40**

		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource management, and loss of biodiversity.	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental issues.	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO 1	PO 2	PO3	PO4	PO 5	PO6	PO 7	PO 8	PO 9	PSO 1	PSO 2	PSO3	PSO4	PSO5
SEN52105	**Environmental Microbiology and Biotechnology**	2	3	2	2	2	3	3	3	2	3	3	2	2	1

1 = weakly mapped

2 = moderately mapped

3 = strongly mapped

Model Question Paper

Name: **Enrolment No:**	ADAMAS UNIVERSITY PURSUE EXCELLENCE

Course: SEN52105 – Environmental Microbiology and Biotechnology

Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**

Semester: Odd 2020-21 **Max. Marks: 40**

Total no. of questions: 12

Instructions:

Attempt all (five) questions from **Section A** (each carrying 2 marks); any **Four Questions** from **Section B** (each carrying 5 marks); any one question from **Section C** (carrying 10 marks)**.**

Section A (Attempt **all the questions)**			
1.	Differentiate between DNA and RNA.	**U**	**CO1**
2.	What are transmissible diseases?	**R**	**CO4**
3.	Define biomonitoring.	**R**	**CO5**
4.	Write the basic concept of epidemiology.	**U**	**CO3**
5.	Which procedures can be used to isolate a pure culture of bacterium from mix population?	**E**	**CO1**
Section B (Attempt any **four questions)**			
6.	Explain the procedure to perform the presumptive test to estimate the MPN of water. Highlight the importance of MPN test in drinking water	**An**	**CO3**
7.	Write down the types of bioremediation and discuss its constraints and priorities.	**U**	**CO5**
8.	Explain the four types of microbial habitats found in aquatic habitats.	**R**	**CO2**
9.	Draw the Bacterial Growth Curve and explain about each stage.	**U**	**CO1**
10.	What are different approaches available for production of biological hydrogen production?	**An**	**CO6 and CO7**
Section C (Attempt any **one question)**			
11.	In an aeration tank of volume 10,000 m^3, the flow rate was 2500 m^3/d. The concentration of mixed liquor suspended solid and effluent solids were 250 g/L and 125 g/L respectively. If the amount of sludge wasted is 100 kg/d, calculate the sludge age. (b) Calculate the time it will take to increase the cell number from 10^4 CFU/ml to 10^8 CFU/ml assuming a generation time of 1.5 hr. (c) How many mg/L of Cr_2O^{2-} are consumed if the COD of a wastewater sample is 450 mg/L.	**C**	**CO7**
12.	Explain about pesticide degradation pattern and how the petroleum products are degraded?	**E**	**CO6**

SEN52107	Elective I Remote Sensing GIS for Environmental Planning and Management	L	T	P	C
Version 1.0	**Contact Hours – 60**	4	0	0	4
Pre-requisites/Exposure	Basic physics, chemistry, and mathematics.				
Co-requisites	-				

Course Objectives

1. This course aims at introducing concept, principles and applications of Geographic Information Systems (GIS). Course also aims to develop the skill of using software and other tools of GIS in students.
2. This course aims to introduce students on concept of Remote Sensing (RS), overview of RS image processing and its' applications.
3. To provide background knowledge and understanding of principles of RS, RS Sensors and system.
4. To overview of information retrieval of earth surface features using multi-resolution, multi-scale and multi-temporal imagery
5. Introduction of image processing and classification techniques
6. Enable spatial and temporal thinking to relate remote sensing for real-world applications.

Course Outcomes

On completion of this course, the students will be able to

CO1.	Provide and select the type of remote sensing technique / data for required purpose
CO2.	Identify the earth surface features from satellite images
CO3.	Analyze the energy interactions in the atmosphere and earth surface features
CO4.	Prepare thematic maps suitable for pollution prevention, environmental remediation and monitoring and ecosystem management.
CO5.	Analyse the basic components of GIS
CO6.	Classify the maps, coordinate systems and projections
CO7.	Formulate and solve geospatial problems in relation to various domains of ecology and environment

Course Description: The objective of this course aims at providing students with knowledge and in-depth understanding of techniques in digital image processing for remote sensing data analysis. This course emphasizes on implementation of algorithms as computer programs. The techniques taught in this course have application in several fields dealing with image data. This course also aims to develop the skill on understanding, handling and processing of remote sensing data. The course has specific objectives to: i) train students on using various remote sensing data types / formats, imagery products; ii) carryout image and data preprocessing techniques for handling radiometric and geometric corrections; iii) impart knowledge of principles and methods of multi-resolutions and multi-spectral data fusion, multi-temporal processing and accuracy assessment; iv) develop data processing automation through batch processing. It conveys the basics of terrestrial and satellite digital photogrammetry. It aims at providing basic photogrammetry concept, procedures and processing task. Insights on products

quality and error analysis are also considered and explained with various methods. Basic concepts of terrestrial and aerial laser scanning will be also given. It is designed to provide fundamental knowledge and theories of microwave remote sensing. The fundamentals of electromagnetics, both real aperture and synthetic aperture radar systems will be introduced including physical principles.

Detailed syllabus

Unit I: Remote Sensing **(5L)**

Fundamental physics of Remote Sensing; Platforms and Sensors; Thermal and Microwave Remote Sensing; Hyperspectral Remote Sensing and Lidar; Application of Remote Sensing.

Unit I: Introduction to Geoinformatics **(10L)**

Definition, Philosophy & Historical evolution of GIS, Basic concepts about spatial information, Spatial vs. non-spatial data, Spatial data models – Raster and Vector, Components of GIS, Hardware/software requirements for GIS, GIS Vs Cartography, Basics of Cartography: Map Scale, Categories of Maps, Grids and Graticules, Photogrammetry; Surveying; GPS

Unit II: Data structure and format **(8L)**

Raster Data & its Representation: Data Structure, Data Compression (block code, chain code, run length code, quadtree), Raster file formats, Vector data representation: Data Structure, Non-topological and topological vector data models, Non-topological and topological vector file formats, Comparison between Raster & Vector Data.

Unit III: Data Input and Geo-correction **(10L)**

Sources of Spatial Data (Raster and Vector), Data Acquisition Through Scanners and Digitizers, Methods of Digitization (Manual vs. Automated), Geometric Transformations of Raster and Vector Data (Affine Transformation and Transformation Coefficients). RMS Error, Sources of Errors in spatial data and, Spatial Data Quality: Accuracy, Precision, Error and Uncertainty.

Unit IV: Database Management System **(12L)**

Advantage of DBMS in context of GIS, RDBMS: Concepts and specific features, Object-Oriented approach to GIS data management, Basic Concepts of Geodatabase, Linkage between spatial and non-spatial data.

Unit V: Spatial Data Analysis and Visualisation **(15L)**

Raster Data Analysis Techniques – Local, Focal, Global and Zonal, Vector Data Analysis- Map Manipulation Techniques, Buffering Overlay Analysis, Distance Measurements, Measuring and Mapping Change, Interpolation (DEM Generation). Vector and Raster Data Query: Logical Expressions, Geographic Visualization: Socio-economic thematic maps, Current Issues and Trends in GIS.

Text Books

1. James B. Campbell & Randolph H. Wynne., Introduction to Remote Sensing, The Guilford Press, 2011.

2. Charles Elach & Jakob van Zyl., Introduction to the physics and techniques of Remote Sensing, John Wiley & Sons publications, 2006.
3. Lillesand T.M & Kiefer R.W., Remote Sensing and Image Interpretation, John Wielyand Sons, 2008.

Reference books:

1. Chritian Matzler., Thermal microwave radiation: Applications for remote sensing, The
2. institution of Engineering and Technology, London, 2006.
3. Rees, W. G., Physical principles of Remote Sensing, Cambridge University Press,
4. Paul Curran P.J., Principles of Remote Sensing, ELBS Publications, 1985.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Elective I Paper Name: Remote Sensing GIS for Environmental Planning and Management **Course Code : SEN52107**		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO 1	Provide and select the type of remote sensing technique / data for required purpose	**PO2, PO4, PO5, PO8, PO9, PSO1, PSO3, PSO4**
CO 2	Identify the earth surface features from satellite images	**PO1, PO2, PO3, PO4, PO5, PO 6, PO7, PSO1, PSO3, PSO4**
CO 3	Analyze the energy interactions in the atmosphere and earth surface features	**PO1, PO2, PO4, PO6, PO7, PO8, PSO2, PSO3**
CO 4	Prepare thematic maps suitable for pollution prevention, environmental remediation and monitoring and ecosystem management.	**PO1, PO2, PO4, PO6, PO7, PSO1, PSO4**
CO 5	Analyse the basic components of GIS	**PO2, PO4, PO5, PO7, PSO2**
CO 6	Classify the maps, coordinate systems and projections	**PO2, PO4, PO5, PO7, PSO1, PSO2**
CO 7	Formulate and solve geospatial problems in relation to various domains of ecology and environment	**PO2, PO4, PO5, PO7, PSO1, PSO2**

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	**Internal**	**Attendance**	**Mid Term**	**End Term**
Weightage (%)	**30**	**10**	**20**	**40**

		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
SEN52107	**Elective I Sensing GIS for Environmental Planning and Management**	2	3	3	3	3	2	3	3	3	2	2	2	3	1

1 = weakly mapped

2 = moderately mapped

3 = strongly mapped

Model Question Paper

Name: **Enrolment No:**	

Course: SEN52107 – Elective I Remote Sensing GIS for Environmental Planning and Management
Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**
Semester: Odd 2020-21 **Max. Marks: 40**
Total no. of questions: 12

Instructions:
Attempt all (five) questions from **Section A** (each carrying 2 marks); any **Four Questions** from **Section B** (each carrying 5 marks); any one question from **Section C** (carrying 10 marks)**.**

Section A (Attempt **all the questions)**			
1.	What are the basic characteristics of map?	**R**	**CO4**
2.	What do you mean by network tracing?.	**R**	**CO6**
3.	List out the key components of Geographic Information system.	**R**	**CO8**
4.	What do you mean by Burn mapping?	**U**	**CO3**
5.	Discuss in brief nominal spectral resolution.	**U**	**CO2**
Section B (Attempt any **four questions)**			
6.	Explain Height, depth, site, situation and association relating to elements of visual interpretation.	**An**	**CO1**
7.	What are raster data models and vector data models? Write the basic differences between raster and vector data models.	**Ap**	**CO3**
8.	Explain the tone, colour, texture and pattern relating to elements of visual interpretations.	**E**	**CO1**
9.	Explain the application of remote sensing in flood zone mapping.	**R**	**CO4**
10.	Define proximity and what do you mean by optimal path	**R**	**CO8**
Section C (Attempt any **one question)**			
11.	What do you mean by Vector overlay? Explain Point-in-polygon overlay, Lineon-polygon overlay, Polygon-on-polygon overlay.	**E**	**CO1**
12.	Explain how satellite imagery can be used for extraction of watershed parameters stating their advantages and advantages. Write a short note on land use and land cover.	**Ap**	**CO1**

SEN52109	Elective I Soil Science	L	T	P	C
Version 1.0	**Contact Hours – 60**	4	0	0	4
Pre-requisites/Exposure	Basic soil science.				
Co-requisites	-				

Course Objectives

1. Understanding of process of pedogenesis.
2. Concepts of soil physics, chemistry and biology.
3. Knowledge of management of soil pollution.
4. Become aware of environment and health impacts soil.
5. Understand engineering, financial and technical options for soil remediation.

Course Outcomes

On completion of this course, the students will be able to

CO1.	Understand the role of soil forming factors and processes in soil formation
CO2.	Understand various soil physical, chemical and biological properties and their impact on the environment.
CO3.	Evaluate various modern concepts of soil classification and the methods and types of soil survey and soil maps
CO4.	Apply principles of reclamation and management of soil physical and chemical constraints
CO5.	Design the application of manures, fertilizers and soil fertility management through various approaches.
CO6.	Illustrate knowledge on different pesticides, their nature and, mode of action and their fate in soil so as to monitor their effect on the environment

Course Description: This course provides a general introduction to soils. It includes terminology used in soil science; soil and their physical, chemical and biological properties; soil formation; soils and spatial variability; soils inventory; examples of the use of soil information in crop production estimation and land use and management planning. Soils are fundamental to ecosystem science. A systems approach is used to investigate how soils look and function. Topics investigated include soil structure, biology, water, fertility, and taxonomy as well as the human impact on the soil environment. Soil physical properties and interactions as related to soil and water resource management and conservation. Water runoff (leading to soil erosion and surface water contamination); tillage and nutrient management; soil thermal and moisture regimes; solute movement; soil compaction, air and aeration. Nature, activities and role of organisms inhabiting soil. Effects of soil biota on ecosystem function, response to cultural practices, and impacts on environmental quality, including bioremediation of contaminated soils. Interaction of soils with environmental contaminants and the role of soils in pollution control. Examine the sources and properties of anthropogenic soil pollution including emerging contaminants such as PFAS, nanomaterials, microplastics. Apply the principles of soil science to understand the transport, mobilization, and partitioning of contaminants in soil and, in turn, how these contaminants affect ecosystem and human health.

Detailed syllabus

Unit I: Basics of soil science **(10L)**

Soil structure - genesis, types, characterization and management soil structure; soil aggregation, aggregate stability; soil tilth, characteristics of good soil tilth; soil crusting - mechanism, factors affecting and evaluation; soil conditioners; puddling, its effect on soil physical properties; clod formation. Soil water: content and potential, soil water retention, soil-water constants, measurement of soil water content, energy state of soil water, soil-moisture characteristic curve; hysteresis, measurement of soil-moisture potential. Infiltration; internal drainage and redistribution; evaporation; hydrologic cycle, field water balance; soil-plant-atmosphere continuum. Composition of soil air; renewal of soil air - convective flow and diffusion; measurement of soil aeration; aeration requirement for plant growth; soil air management. Modes of energy transfer in soils; energy balance; thermal properties of soil; measurement of soil temperature; soil temperature in relation to plant growth; soil temperature management.

Unit II: Soil Biology and Biochemistry **(10L)**

Soil biota, soil microbial ecology, types of organisms in different soils; soil microbial biomass; microbial interactions; un-culturable soil biota. Microbiology and biochemistry of root-soil interface; phyllosphere; soil enzymes, origin, activities and importance; soil characteristics influencing growth and activity of microflora. Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil; biochemical composition and biodegradation of soil organic matter and crop residues, humus formation; cycles of important organic nutrients. Biodegradation of pesticides, organic wastes and their use for production of biogas and manures; biotic factors in soil development; microbial toxins in the soil. Preparation and preservation of farmyard manure, animal manures, rural and urban composts and vermicompost. Biofertilizers - definition, classification, specifications, method of production and role in crop production.

Unit III: Soil fertility **(10L)**

Soil fertility and soil productivity; nutrient sources - fertilizers and manures; essential plant nutrients - functions and deficiency symptoms. Soil and fertilizer nitrogen - sources, forms, immobilization and mineralization, nitrification, denitrification; biological nitrogen fixation - types, mechanism, microorganisms and factors affecting; nitrogenous fertilizers and their fate in soils; management of fertilizer nitrogen in lowland and upland conditions for high fertilizer use efficiency. Soil and fertilizer phosphorus - forms, immobilization, mineralization, reactions in acid and alkali soils; factors affecting phosphorus availability in soils; phosphatic fertilizers - behaviour in soils and management under field conditions.

Unit IV: Soil Chemistry **(10L)**

Soil colloids: inorganic and organic colloids - origin of charge, concept of point of zero-charge (PZC) and its dependence on variable-charge soil components, surface charge characteristics of soils; diffuse double layer theories of soil colloids, zeta potential, stability, coagulation/flocculation and peptization of soil colloids; electrometric properties of soil

colloids; sorption properties of soil colloids; soil organic matter - fractionation of soil organic matter and different fractions, clay-organic interactions. Ion exchange processes in soil; cation exchange- theories based on law of mass action (Kerr-Vanselow, Gapon equations, hysteresis, Jenny's concept), adsorption isotherms, Donnan-membrane equilibrium concept, clay-membrane electrodes and ionic activity measurement, thermodynamics, statistical mechanics; anion and ligand exchange - innersphere and outer-sphere surface complex formation, fixation of oxyanions, hysteresis in sorption-desorption of oxy-anions and anions, shift of PZC on ligand exchange, AEC, CEC; experimental methods to study ion exchange phenomena and practical implications in plant nutrition. Potassium, phosphate and ammonium fixation in soils covering specific and non-specific sorption; precipitation-dissolution equilibria; step and constant-rate K; management aspects. Chemistry of acid soils; active and potential acidity; lime potential, chemistry of acid soils; sub-soil acidity. Chemistry of salt-affected soils and amendments; soil pH, ECe, ESP, SAR and important relations; soil management and amendments. Chemistry and electrochemistry of submerged soils.

Unit V: Soil Classification, Erosion and Conservation **(10L)**

Concept of soil individual; soil classification systems – historical developments and modern systems of soil classification with special emphasis on soil taxonomy; soil classification, soil mineralogy and soil maps – usefulness. Soil survey and its types; soil survey techniques - conventional and modern; soil series - characterization and procedure for establishing soil series; benchmark soils and soil correlations; soil survey interpretations; soil mapping, thematic soil maps, cartography, mapping units, techniques for generation of soil maps. Landform - soil relationship; major soil groups of India with special reference to respective states; land capability classification and land irrigability classification; land evaluation and land use type (LUT) - concept and application; approaches for managing soils and landscapes in the framework of agro-ecosystem. Soil classification, soils of India. History, distribution, identification and description of soil erosion problems in India. Soil erosion and control; Soil conservation planning; land capability classification; soil conservation in special problem areas such as hilly, arid and semi-arid regions, waterlogged and wet lands. Watershed management - concept, objectives and approach.

Unit VI: Soil pollution **(10L)**

Nature and sources of pollutants – agricultural, industrial, urban wastes, fertilizers and pesticides, acid rains, oil spills etc.; air, water and soil pollutants – their CPC standards and effect on plants, animals and human beings. Sewage and industrial effluents – their composition and effect on soil properties/health, and plant growth and human beings; soil as sink for waste disposal. Pesticides – their classification, behaviour in soil and effect on soil micro- organisms. Toxic elements – their sources, behaviour in soils, effect on nutrients availability, effect on plant and human health. Soil Pollution: Types, sources and consequences. Sampling Methods. Specifications for disposal of sewage & effluent on land for irrigation & ground water recharge. Methodology of wastewater disposal on land in India. Impact of usage of land for solid waste disposal both municipal solid waste & industrial solid wastes (fly ash from thermal power station, lime sludge from pulp & paper mills). Disposal of hazardous solid waste(heavy metals, toxic organic compounds) on land & its impact on soil pollution. Deterioration of soil due to

mining activities Case study of restoration of land due to disposal to fly ash, b. dumping overburden & tailing in iron ore extraction.

Text Books

1. Brady, N.C. and Weil, R.R., The nature and properties of soil, Pearson
2. Sathyanarayana, E., Kumar, M.S. and Hadole S.S., Soil Science Treatise, Narendra Publishing House.
3. Rathinasamy, A. and Saliha, B.B., Fundamentals of Soil Science, Scientific Publisher.
4. Arya, R.L. and Khan, K., Fundamentals of Soil Science, Scientific Publishers.
5. Russel, E.J., The fertility of soil, Cambridge University Press.

Reference books

1. Soil Science: An Introduction, Indian Society of Soil Science.
2. Havlin, J.L., Tisdale, S.L., Nelson, W.L. and Beaton, J.D., Soil fertility and fertilizers, Pearson Education India.
3. Biswas, T. and Mukherjee, S., Textbook of Soil Science, McGraw Hill Education.
4. Das, D.K., Introductory Soil Science, Kalyani Publishers.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Elective I Soil Science		**Course Code : SEN52109**
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO 1	Understand the role of soil forming factors and processes in soil formation	**PO2, PO4, PO5, PO8, PO9, PSO1, PSO3, PSO4**
CO 2	Understand various soil physical, chemical and biological properties and their impact on the environment.	**PO1, PO2, PO3, PO4, PO5, PO 6, PO7, PSO1, PSO3, PSO4**
CO 3	Evaluate various modern concepts of soil classification and the methods and types of soil survey and soil maps	**PO1, PO2, PO4, PO6, PO7, PO8, PSO2, PSO3**
CO 4	Apply principles of reclamation and management of soil physical and chemical constraints	**PO1, PO2, PO4, PO6, PO7, PSO1, PSO4**
CO 5	Design the application of manures, fertilizers and soil fertility management through various approaches.	**PO2, PO4, PO5, PO7, PSO2**
CO 6	Illustrate knowledge on different pesticides, their nature and, mode of action and their fate in soil so as to monitor their effect on the environment	**PO2, PO4, PO5, PO7, PSO1, PSO2**

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	**Internal**	**Attendance**	**Mid Term**	**End Term**
Weightage (%)	**30**	**10**	**20**	**40**

		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
SEN52109	**Soil Science**	2	3	3	3	3	2	3	3	3	2	2	2	3	1

1 = weakly mapped

2 = moderately mapped

3 = strongly mapped

Model Question Paper

Name: **Enrolment No:**	

Course: SEN52109 – Soil Science

Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**
Semester: Odd 2020-21 **Max. Marks: 40**
Total no. of questions: 12

Instructions:
Attempt all (five) questions from **Section A** (each carrying 2 marks); any **Four Questions** from **Section B** (each carrying 5 marks); any one question from **Section C** (carrying 10 marks)**.**

Section A (Attempt **all the questions)**			
1.	Mention any two sources of alkalinity in soil.	**Ap**	**CO2**
2.	Weed control reduce water loss. Explain the mechanism.	**An**	**CO1**
3.	What is the effect of soil pH on the availability of phosphorous.	**R**	**CO4**
4.	Rearrange the following soil orders from the least to the most highly weathered: oxisols, alfisols, mollisols, entisols and inceptisols.	**U**	**CO2**
5.	What is loess?	**U**	**CO5**
Section B (Attempt any **four questions)**			
6.	What are organoclays and how can they be used to help remediate soils polluted with non-polar organic compounds?	**An**	**CO5**
7.	Write an explanatory note on phytoremediation.	**Ap**	**CO3**
8.	What is leachate? With neat sketch, discuss the role of leachate movement in soil pollution.	**E**	**CO1**
9.	Explain why compost is environmentally sustainable than peat for use in potting media and as an amendment for golf course greens.	**R**	**CO4**
10.	Explain why soil taxonomy is said to be a hierarchical classification system.	**R**	**CO2**
Section C (Attempt any **one question)**			
11.	Two different timber harvest methods are being tested on adjacent forest plots with clay loam surface soils. Initially the bulk density on the surface soil in both plots was 1.1Mg/m^3. One year after the harvest operations, plot A soil had a bulk density of 1.48Mg/m^3, while that in plot B was 1.29Mg/m3. Interpret these values with regards to the relative merits of systems A and B, and the likely effects on the soil's functions in the forest ecosystem.	**E**	**CO1**
12.	What is the main purpose of digging soil pits as part of making a soil survey? What are the advantages of using aerial photos as a map base in making a soil survey?	**Ap**	**CO6**

SEN52201	Environmental computation Lab	L	T	P	C
Version 1.0	**Contact Hours – 60**	0	0	4	2
Pre-requisites/Exposure	Basic physics, chemistry, and mathematics.				
Co-requisites	-				

Course Objectives

1. This course aims at introducing concept of mathematical modelling of pollutants.
2. This course aims to introduce students on concept of environmental economic models.
3. To provide background knowledge and understanding of principles of MATLAB.
4. To provide exposure to students in gaining knowledge on concepts and applications of ANDROID apps in environmental monitoring.

Course Outcomes

On completion of this course, the students will be able to

CO1.	Interpret ancillary information for geospatial modelling.
CO2.	Identify the different modes of atmospheric dispersion of pollutants.
CO3.	Develop demographic models.
CO4.	Prepare economic models on environment.
CO5.	Develop programming in MATLAB platform.
CO6.	Illustrate scope of ANDROID apps in environmental management.

List of Experiments:

1. Geospatial modelling emission of greenhouse gas or other pollutants emanating from various modes of automobile transport/vehicles.
2. Modelling of dispersion of various atmospheric pollutants.
3. Life-cycles analysis of various products, consumer goods, and ecological footprint analysis.
4. Modelling of population growth, increase in consumerism, rise in GDP and allied increase in greenhouse gases and increase in tapping of natural resources.
5. Mathematical models for epidemiology and ecology.
6. Model to explain dynamics of vehicle demand, production, purchase, usage and scrapping and associated economic facets like tax, duty, subsidies etc.
7. Meteorological modelling.
8. Information tools for Environmental Data Management.
9. Fundamentals of programming using MATLAB.
10. Android based environmental applications.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Environmental computation Lab		Course Code : SEN52201
	Course Outcomes (COs)	**Mapped Program Outcomes**

CO 1	Interpret ancillary information for geospatial modelling.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 2	Identify the different modes of atmospheric dispersion of pollutants.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 3	Develop demographic models.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 4	Prepare economic models on environment.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 5	Develop programming in MATLAB platform.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO6	Illustrate scope of ANDROID apps in environmental management.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	Mid Term	Attendance	Class Assessment	End Term
Weightage (%)	20	10	30	40

		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource management, and loss of	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental issues.	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
SEN52201	**Environmental computation Lab**	3	2	2	1	2	3	3	2	3	3	-	1	3	1

1 = weakly mapped

2 = moderately mapped

3 = strongly mapped

Model Question Paper

Name: **Enrolment No:**	

Course: SEN52201 – Environmental computation Lab
Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**
Semester: Odd 2020-21 **Max. Marks: 40**
Total no. of questions:

Instructions:
Attempt all questions**.**

Section A (Attempt **all the questions)**

1.	Create nonlinear grey box time series models. Time series models are models not using any measured inputs. Three idealized ecological systems are to be studied where two species either: compete for the same food, or: are in a predator-prey situation	An	CO5

SEN52203	Elective I Remote Sensing and GIS for Environmental Planning and Management Lab	L	T	P	C
Version 1.0	**Contact Hours – 60**	0	0	4	2
Pre-requisites/Exposure	Basic physics, chemistry, and mathematics.				
Co-requisites	-				

Course Objectives

1. This course aims at introducing concept, principles and applications of Geographic Information Systems (GIS). Course also aims to develop the skill of using software and other tools of GIS in students.
2. This course aims to introduce students on concept of Remote Sensing (RS), overview of RS image processing and its' applications.
3. To provide background knowledge and understanding of principles of RS, RS Sensors and system.
4. To provide exposure to students in gaining knowledge on concepts and applications leading to modelling of earth resources management using Remote Sensing
5. To acquire skills in storing, managing digital data for planning and development.
6. To acquire skills in advance techniques such as hyper spectral, thermal and LiDAR scanning for mapping, modelling and monitoring.

Course Outcomes

On completion of this course, the students will be able to

CO1.	Interpret ancillary information of remotely sensed data
CO2.	Identify the different features from imageries
CO3.	Organise images and prepare thematic maps
CO4.	Prepare thematic maps suitable for pollution prevention, environmental remediation and monitoring and ecosystem management.
CO5.	Prepare the different geospatial layers
CO6.	Classify the maps, coordinate systems and projections

Course Description: The objective of this course aims at providing students with knowledge and in-depth understanding of techniques in digital image processing for remote sensing data analysis. The course has specific objectives to: i) train students on using various remote sensing data types / formats, imagery products; ii) carryout image and data preprocessing techniques for handling radiometric and geometric corrections; iii) impart knowledge of principles and methods of multi-resolutions and multi-spectral data fusion, multi-temporal processing and accuracy assessment; iv) develop data processing automation through batch processing.

List of Experiments:

1. Familiarisation with Hardware and software
2. Study of spectral and image characteristics of optical data for identification/characterization of major landcover features.
3. Study of given area in B/W, B/W IR, Colour IR Imagery, on screen image interpretation: Comparison of images displayed on RGB and HIS display system
4. Study of Satellite imagery (B/W) in different bands and visual interpretation
5. Acquisition of Satellite Images: Through UAV mode, Processing of UAV images
6. Understanding formats of satellite images and how to practically exchange them for LU/LC and Vegetation mapping Interpretation of Images with typical natural features
7. Interpretation of Images for ocean and coastal monitoring
8. Image characteristics of geological structures and major land forms, Exploring sample LIDAR data
9. Thematic layer extraction from multidimensional remote sensing data from online resources
10. Interpretation of Thermal Image for land cover identification
11. Image enhancement techniques: Contrast Enhancement, Density Slicing and Transfer functions, Filtering: High Pass, Low Pass, Edge Enhancement
12. Principal Component Analysis, Spectral Indices
13. Interpretation of SAR image for land cover identification.
14. Familiarization with GIS Software, Georeferencing and Projection
15. GIS Data Creation - Digitization and Topology editing, GIS Data Creation - Domain Values, Data Types & Attribution
16. Spatial and Non-Spatial Queries, Vector-based Spatial Analysis, Raster-based Spatial Analysis
17. Network Analysis, Generation of DEM, Map Composition
18. Demonstration on different Types of GNSS receivers; Checking of existing map coordinates using IRNSS Receiver, Survey of small area using IRNSS receiver
19. Data Collection and Updation using Mobile GIS (Qrealtime)

Reference books

1. Lillesand T.M and Kiefer R.W., Remote Sensing and Image Interpretation, John Wiley and Sons, 2008.
2. ArcGIS 10.1 user manuals, 2013
3. ERDAS Imagine 2013 user manual
4. Kraak, M. and Brown, A. Web Cartography: Development and Prospects, Taylor and Francis, London, 2001.
5. Tereshenkov, A. Web GIS Application in Local Government, VDM Verlag, 2009.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Elective I Remote Sensing and GIS for Environmental Planning and Management Lab **Course Code : SEN52203**		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO 1	Interpret ancillary information of remotely sensed data	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 2	Identify the different features from imageries	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 3	Organise images and prepare thematic maps	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 4	Prepare thematic maps suitable for pollution prevention, environmental remediation and monitoring and ecosystem management.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 5	Prepare the different geospatial layers	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO6	Classify the maps, coordinate systems and projections	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	**Mid Term**	**Attendance**	**Class Assessment**	**End Term**
Weightage (%)	**20**	**10**	**30**	**40**

		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource management, and loss of	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental issues.	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
SEN52203	**Elective I Remote Sensing and GIS for Environmental Planning and Management Lab**	3	2	2	1	2	3	3	2	3	3	-	1	3	1

1 = weakly mapped

2 = moderately mapped

3 = strongly mapped

Model Question Paper

Name: **Enrolment No:**	

Course: SEN52203 – Elective I Remote Sensing and GIS for Environmental Planning and Management Lab

Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**
Semester: Odd 2020-21 **Max. Marks: 40**
Total no. of questions:

Instructions:
Attempt all questions**.**

Section A (Attempt **all the questions)**

1.	Study the maps provided and compare between Raster and Vector Model for representing geographic features; illustrate by figures.	An	CO2

SEN52205	Elective I Soil Science Lab	L	T	P	C
Version 1.0	**Contact Hours – 60**	0	0	4	2
Pre-requisites/Exposure	Basic physics, chemistry, biology and mathematics.				
Co-requisites	-				

Course Objectives

1. Understanding of process of pedogenesis.
2. Concepts of soil physics, chemistry and biology.
3. Knowledge of management of soil pollution.
4. Become aware of environment and health impacts soil.
5. Understand engineering, financial and technical options for soil remediation.

Course Outcomes

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

CO1.	Identify the physical, chemical, and biological properties and processes of soils and relate these to the way that societies use and abuse soils.
CO2.	Acquire a working knowledge of the technical terminology of soil science and begin developing observational skills needed to describe and/or locate soil properties for specific locations and to interpret those properties for various uses.
CO3.	Develop their own fieldwork program.
CO4.	Recognize and explain various land use and management practices and to select those that are appropriate at a given site.
CO5.	Describe the major sources of water, soil, and sediment pollution and methods for their management.
CO6.	Evaluate the impact of land use and management decisions on agricultural productivity and sustainability, environmental and ecological health, and on community relationships.

Course Description:

Laboratory exercise and field trips designed to develop student competency in soil description, analysis, and assessment. This laboratory course is also designed for students who plan to work directly with soils, make land use and management decisions, or to be involved in projects requiring practical application of soil science principals. By conducting weekly laboratory and field exercises and writing reports on their work, students will deepen their understanding of, and learn to apply, the fundamental soil properties and processes. This laboratory course will provide foundational learning in soil science and prepare students for further research in soil science courses. This laboratory course is also designed to provide students with hands on experience in analytical procedures for soil assessment, testing, and interpretation, as well as field experience in observing, characterizing and describing soils.

List of Experiments:

1. Aggregate analysis - dry and wet measurement of soil-water content by different methods
2. Measurement of soil-water potential by using tensiometer and gypsum blocks.

3. Determination of soil-moisture characteristics curve and computation of pore-size distribution
4. Determination of hydraulic conductivity under saturated and unsaturated conditions.
5. Chemical analysis of soil for total and available nutrients.
6. Analysis of plants for essential elements.
7. Determination of CEC and AEC of soils
8. Analysis of equilibrium soil solution for pH, EC, Eh by the use of Eh-pH meter and conductivity meter.
9. Determination of point of zero-charge and associated surface charge characteristics by the serial potentiometric titration method.
10. Potentiometric and conductometric titration of soil humic and fulvic acids.
11. Determination of titratable acidity of an acid soil by BaCl2-TEA method
12. Determination of lime requirement of an acid soil by buffer method.
13. Determination of gypsum requirement of an alkali soil.
14. Determination of different soil erodibility indices - suspension percentage, dispersion ratio, erosion ratio, clay ratio, clay/moisture equivalent ratio, percolation ratio, raindrop erodibility index
15. Computation of rainfall erosivity index (EI30) using rain gauge data.
16. Determination of soil microbial population
17. Soil microbial biomass
18. Decomposition of organic matter in soil.

Text Books

1. Brady, N.C. and Weil, R.R., The nature and properties of soil, Pearson
2. Sathyanarayana, E., Kumar, M.S. and Hadole S.S., Soil Science Treatise, Narendra Publishing House.
3. Rathinasamy, A. and Saliha, B.B., Fundamentals of Soil Science, Scientific Publisher.
4. Arya, R.L. and Khan, K., Fundamentals of Soil Science, Scientific Publishers.
5. Russel, E.J., The fertility of soil, Cambridge University Press.

Reference books

1. Soil Science: An Introduction, Indian Society of Soil Science.
2. Havlin, J.L., Tisdale, S.L., Nelson, W.L. and Beaton, J.D., Soil fertility and fertilizers, Pearson Education India.
3. Biswas, T. and Mukherjee, S., Textbook of Soil Science, McGraw Hill Education.
4. Das, D.K., Introductory Soil Science, Kalyani Publishers.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Elective I Soil Science Lab		Course Code : SEN52205
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO 1	Identify the physical, chemical, and biological properties and processes of soils and relate these to the way that societies use and abuse soils.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 2	Acquire a working knowledge of the technical terminology of soil science and begin developing observational skills needed to describe and/or locate soil properties for specific locations and to interpret those properties for various uses.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 3	Develop their own fieldwork program.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 4	Recognize and explain various land use and management practices and to select those that are appropriate at a given site.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 5	Describe the major sources of water, soil, and sediment pollution and methods for their management.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO6	Evaluate the impact of land use and management decisions on agricultural productivity and sustainability, environmental and ecological health, and on community relationships.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	Mid Term	Attendance	Class Assessment	End Term
Weightage (%)	**20**	**10**	**30**	**40**

		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource management, and loss of	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental issues.	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
SEN52205	**Elective I Soil Science Laboratory**	3	2	2	1	2	3	3	2	3	3	-	1	3	1

1 = weakly mapped

2 = moderately mapped

3 = strongly mapped

Model Question Paper

Name: **Enrolment No:**	

Course: SEN52205 – Elective I Soil Science Lab

Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**
Semester: Odd 2020-21 **Max. Marks: 40**
Total no. of questions:

Instructions:
Attempt all questions**.**

Section A (Attempt **all the questions)**

1.	Estimate organic carbon and organic matter content in soil (Walkley and Black's method)	An	CO2
2.	Horizon wise Soil samples should be collected from typical profile as per procedure described below: 1) Locate sample site away from roads, houses, and constructions sites, etc. 2) Dig a fresh rectangular pit at least 1.5 metres deep for master and other profile studies. 3) Dig a small pit 1-meter X 1 meter X 50 cm deep for grid points. 4) Clean the profile facing the sun with appropriate tool and demarcate horizons for their morphological descriptions. 5) After describing the horizons, collect the soil sample from the surface horizon with an appropriate implement and place it in a plastic-coated bag for micronutrient analysis. 6) The soil samples, horizon wise may be collected from the bottom upwards using appropriate tools, Divide horizons thicker than 30 cm or variation in soil character and sample each half separately. 7) Discard fragments larger than 7.5 cm. 8) Collect in each cloth bag (3-4 kg capacity) with a slightly larger polythene bag. 9) Insert the label between the two bags. 10) Label the sample for micronutrient analysis prominently with as M on the bag. These samples have to be specially handled in a special laboratory for processing. 11) The other soil samples have to be sent to laboratories for their analysis. Note : Collect two bags of samples from the surface horizon or layer, one for micronutrient analysis and the other for general analysis. The following soil macro morphological characteristics should be studies. 1.The number of horizons in profile	Ev	CO3

	2. Thickness of horizon and profile depth 3.Colour of each horizon 4. Texture of soil of each horizon. 5 Root penetration 6. Concretions, nodules. 7.Natural vegetation 8. Topography 9.Parent rock, solum depth 10. Consistency.		

SEN52207	Enviornmental Microbiology and Biotechnology Lab	L	T	P	C
Version 1.0	**Contact Hours – 60**	0	0	4	2
Pre-requisites/Exposure	Basic physics, chemistry, biology and mathematics.				
Co-requisites	-				

Course Objectives

1. To Obtain information, design experiments and interpret results
2. To Develop analytical and synthesis skills.
3. To Develop bioassays and apply biotechnological processes.
4. To Diagnose and solve environmental problems regarding the biological environment.

Course Outcomes

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

CO1.	Demonstrate safe laboratory practices and strong report writing skill
CO2.	Understand and criticize scientific literature
CO3.	Employ a variety of laboratory techniques, including isolation, enumeration, basic genome analysis and functional assays
CO4.	Explain the distribution of microbes in several different environments, including water, sediments, soil and air
CO5.	Recognize and explain the role of microorganisms in degradation of natural organic compounds and selected pollutants
CO6.	Analyse and demonstrate the microbiological characteristics of water
CO7.	Identify the microbial contamination in food

Course Description:

Laboratory exercise and field trips designed to develop student competency in environmental microbiology, analysis, and assessment. This laboratory course is also designed for students who plan to be involved in projects requiring practical application of environmental microbiology and biotechnology principals. By conducting weekly laboratory and field exercises and writing reports on their work, students will deepen their understanding of, and learn to apply, the fundamental of microorganisms present in the soil. This laboratory course is also designed to provide students with hands on experience in analytical procedures for assessment of environmental sample including soil, water and air, interpretation of results as well as field experience and sampling techniques.

List of Experiments:

1. Laboratory operations, safety and reporting techniques
2. Preparation of glassware, media and sterilization, aseptic techniques
3. Preparation of pure culture and aseptic transfer of pure culture of bacteria.
4. Staining of microorganisms.
5. Measurement of cell number in a culture.
6. Isolation of environmental microorganisms from soil, water and air

7. Enumeration and identification of microorganisms from environmental sample
8. Isolation of bacteriophage.
9. Microbial antibiosis
10. Antibiotic assay.
11. Bacterial survival against UV irradiation and mutagenesis
12. Transformation using isolated plasmid DNA.
13. Microbial examination of water.
14. Bacteriological testing of food products.
15. Microbial degradation of hydrocarbons

Text Books

1. Maier, R.M., Pepper I.L., Gerba, C.P., Environmental Microbiology, Academic Press
2. Pelczar Jr., M.J., Chan, E.C.S. and Kreig, N.R., Microbiology, 5th Edition, McGraw-Hill Publishing Co. Ltd., New Delhi, 1993.
3. Brock Biology of Microorganisms, 13th Edition, Prentice Hall Publication
4. Patrick K. Jjemba., Environmental Microbiology: Principles and Applications.
5. Glazer, A.N., Nikaido, H., Microbial Technology, 2nd Edition, Cambridge University Press

Reference books

1. Bitton, G., Wastewater Microbiology, Wiley-Liss Inc., New York, 1994
2. Prescott's Microbiology, 11th Edition, McGraw Hill Publishers
3. Adams, M.R., Food Microbiology, New Age Publication
4. Pajarathinam., R., Medical Microbiology, New Age Publication
5. Kun, L.Y., Microbial Biotechnology: Principles and Applications, World Scientific Publishing Company

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Environmental Microbiology and Biotechnology Lab		**Course Code : SEN52207**
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO 1	Demonstrate safe laboratory practices and strong report writing skill	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 2	Understand and criticize scientific literature	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 3	Employ a variety of laboratory techniques, including isolation, enumeration, basic genome analysis and functional assays	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**

CO 4	Explain the distribution of microbes in several different environments, including water, sediments, soil and air	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 5	Recognize and explain the role of microorganisms in degradation of natural organic compounds and selected pollutants	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO6	Analyse and demonstrate the microbiological characteristics of water	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO7	Identify the microbial contamination in food	**PO1, PO2, PO5, PO7, PSO1, PSO2, PSO4**

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

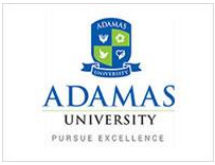
Examination Scheme:

Components	Mid Term	Attendance	Class Assessment	End Term
Weightage (%)	20	10	30	40

		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource management, and loss of	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental issues.	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
SEN52207	**Environmental Microbiology and Biotechnology**	3	2	2	1	2	3	3	2	3	3	3	1	3	1

1 = weakly mapped
2 = moderately mapped
3 = strongly mapped

Model Question Paper

Name: **Enrolment No:**	

Course: SEN52207 – Environmental Microbiology and Biotechnology Lab
Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**
Semester: Odd 2020-21 **Max. Marks: 40**
Total no. of questions:

Instructions:
Attempt all questions**.**

Section A (Attempt **all the questions)**

1.	Evaluate and isolate the various types of microorganisms present in the given water sample using proper techniques.	Ev	CO4
2.	Analyse the given food sample for presence of any microorganisms	An	CO7
3.	Identify the gram-positive and gram-negative bacteria in the water sample and the food sample	An	CO3

SEN52701	Excursion	L	T	P	C
Version 1.0		x	x	x	3
Pre-requisites/Exposure					
Co-requisites	-				

Course Objectives

1. To learn the tools and techniques of conducting field survey.
2. To learn techniques of data collection, data analysis and report writing specific to physical and socio-economic issues of the selected study area.
3. To learn the basic skills required for disaster preparedness planning through field based case studies.

Course Outcomes

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

CO 1	Identify appropriate tools and techniques necessary to conduct field survey.
CO 2	Interpret physical and socio-economic status of the study area based on analysis of the collected data.
CO 3	Identify appropriate tools and techniques to prepare disaster preparedness plan.

Course Description: Excursions are enriching experiences for students to test their knowledge gained throughout the program. This course is designed to gain a new knowledge or clarifying concepts learned in the classroom. Field excursion will provide opportunities to the students to explore the knowledge of physical, social and cultural environment to find the solution for environmental pollution, economic development and social progress. Through this course students can foster interest and motivation to learn and research in various aspects of the subject. Concomitantly writing of the project and their oral presentation will help to improve their thinking, writing and communication skills. This course will consist of lectures, hands-on training to handle various field instruments, field visits, data collection, data analysis, report writing and presentation. The focus will be on enhancing problem identification capacity, data collection from field and their analysis. The majority of class will be invested on field, and in laboratory for data analysis and interpretation. Students will be given tasks for preparing questionnaires, data tabulation and analysis, laboratory testing, identifying and relating the factors for physical and social conditions. Submission of the prepared report and its presentation should be done by the students at the end of the course.

Course content

Excursion to an important place for in-situ biodiversity conservation or ecologically fragile coastal ecosystem or study of physiography.

Modes of Evaluation: Quiz/Assignment/Presentation/Extempore/Written Examination
Examination Scheme:

Components	Internal	Presentation Oral	Presentation Notebook	Understanding of the problem	Methodology for Field Investigation	Content	Analysis	Conclusion
Weightage (%)	**20**	**15**	**15**	**10**	**10**	**10**	**10**	**10**

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO1	Identify appropriate tools and techniques necessary to conduct field survey.	**PO4, PO6, PO9, PSO1**
CO2	Interpret physical and socio-economic status of the study area based on analysis of the collected data.	**PO4, PO5, PO6, PO7, PO9, PSO3**
CO3	Identify appropriate tools and techniques to prepare disaster preparedness plan.	**PO3, PO4, PO5, PO6, PO7, PO8, PO9, PSO3, PSO4**

		Physical Geography Knowledge	Social-Cultural Geography Knowledge	Contextualized Understanding	Data Analysis	Modern Tool Usage	Research Skills	Societal Implication	Environment and Sustainability	Communication and Leadership	Ethics	Understanding Natural & Social processes	Resource Management	Data analysis and Research Skills	Utilize Modern skills in Decision Making
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
SEN52701	**Excursion**	-	-	2	3	3	3	3	2	3	-	2	-	3	3

1=weakly mapped; 2= moderately mapped; 3=strongly mapped

SEN52102	Environmental Impact Assessment and Regulatory Framework	L	T	P	C
Version 1.0	**Contact Hours – 45**	3	0	0	3
Pre-requisites/Exposure	Basic environmental science				
Co-requisites	-				

Course Objectives

1. Appreciate the purpose and role of EIA in the decision-making process.
2. Understand strengths & limitations of EIA driven environmental management and audit.
3. Interpret options for evaluating environmental and social impacts.
4. Know formats of EIA Report (Environmental Impact Statement, or Environmental Statement).
5. Understand the purpose of developing follow-up procedures, and options for designing these procedures.
6. Students will be able to get basic knowledge of environment, pollution and various principles.
7. To explain the role of law, policy and institutions in the conservation and management of natural resources as well as pollution control
8. To introduce the laws and policies both at the national and international level relating to environment
9. To equip the students with the skills needed for interpreting laws, policies and judicial decisions
10. Students will be able to get the knowledge about Constitutional provisions for the protection of environment.
11. Students will learn about the legal provisions of pollution.
12. Students will get the knowledge about the Environment (protection) Act, powers of central government and state government to make laws and Environment Tribunals

Course Outcomes

On completion of this course, the students will be able to

CO1.	Explain the major principles of environmental impact assessment in India.
CO2.	Discuss the implications of current jurisdictional and institutional arrangements in relation to environmental impact assessment
CO3.	Construct and deconstruct different case studies/examples of EIA in practice
CO4.	Understand the origins and sources of environmental laws, and understand how and by whom environmental laws are made and interpreted.
CO5.	Critically analyse environmental laws within various contexts and to evaluate laws against procedural and substantive criteria.

Course Description: The course is designed to highlight the application value of the theory and practice of EIA as operated internationally to emerging and practicing professionals dealing with the development and implementation of projects modulating development. This course introduces the students to the field of integrated environmental management focusing on procedures, tools and techniques for Environmental Impact Assessment (EIA) with a special

emphasis on impacts caused by human interventions on the multiple dimensions of environment and means of regulating them. Law and policy plays a major role in the conservation and management of natural resources as well as pollution control. This course intends to introduce the students to the vast field of Environmental Law and Policy. The course would be divided into three broad areas. The first part would cover the basic concepts and principles of Environmental Law. This would include judicial precedents, which now forms an essential part of environmental jurisprudence. The second part would be divided into specific introductory modules on forests and wildlife including bio-diversity related laws; Air and Water related laws including mega projects and marine laws; and laws relating to hazardous substances. The third part would discuss the developments at the international level in the field of environmental law. At the end of the course it is expected that the students would be familiar with the overall Environmental Law and Policy regime of the country as well as its international obligations. It is expected that the case studies would equip them with basic knowledge and skills to understand environmental law issues.

Detailed syllabus

Unit I: Laws and Acts guarding environmental concerns **(20L)**

Provisions provided in the Constitution of India regarding Environment; Enviro-Legal system in India: PIL and Public Hearing, National Green Tribunal; Public Policy Strategies in Pollution Control; Indian Forests Act, 1927; Wildlife (Protection) Act, 1972; The Water (Prevention and Control of Pollution) Act, 1974; Forest (Conservation) Act, 1980; Air (Prevention and Control of Pollution) Act, 1981; The Environment (Protection) Act, 1986; Motor Vehicle Act, 1988; Hazardous Wastes (Management and Handling) Rules, 1989; Public Liability Insurance Act, 1991; Biological diversity Act, 2002; Disaster Management Act, 2005; Environmental Impact Assessment Notification, 2006; Coastal Regulation Zone Notification, 2011, Waste Management Rules 2016, Island Protection Zones Notifications, 2011 and 2019.

Unit II: Introduction to Environmental Impact Assessment **(25L)**

Concept of environmental impact, Introduction to Environmental impact assessment (EIA) – definitions, terminology and concepts, Evolution of EIA in the USA, Key features of the National Environmental Policy Act and its implementation and the Council on Environmental Quality (CEQ) guidelines, Role of the USEPA, Evolution of EIA in India, Sustainable development, Generalised EIA process flow chart, Screening, Initial environmental examination (IEE), Scoping, Public participation. Environment Risk assessment, Pollution prevention and Waste minimization, sustainable Development (SD), Life cycle assessment. Global Environmental Issues. EIA - Screening and scoping criteria, Rapid and comprehensive EIA, Impact assessment methods, checklists, matrices, quantitative methods, networks, overlay mapping, Impact prediction and evaluation, Legislative and environmental clearance procedures in India and other countries, Siting criteria, CRZ, Public participation, Resettlement and rehabilitation. Practical applications of EIA, EIA methodologies, Baseline data collection, Prediction and assessment of impacts on physical, biological and socio-economic environment, Environmental management plan, Post project monitoring, initial environmental examination (IEE),environmental impact statement (EIS), environmental appraisal, environmental audit

(EA),Environmental impact factors and areas of consideration, measurement of environmental impact organisation, scope and methodologies of EIA, case studies stressing physical aspects of environment, Evolution of EIA, EIA at project, Regional and policy levels, Strategic EIA, EIA process.

Text Books

1. Environmental Law and Policy in India: Shyam Divan: Armin Rosencranz
2. Divan S. and Rosencranz A. (2005) Environmental Law and Policy in India, 2nd ed., Oxford, New Delhi
3. Leelakrishnan P. (2008) Environmental Law in India, 3rd ed., Lexis Nexis, India
4. Glasson, J., Therivel, R., Chadwick, A. 1994. Introduction to Environmental Impact Assessment. London, Research Press, UK.
5. EIA Notification 2006, MoEFCC, GoI.

Reference books

1. Desai A. (2002) Environmental Jurisprudence, 2nd ed., Modern Law House, Allahabad.
2. Gadgil M. and Guha R. (1995) Ecology and Equity, Oxford, New Delhi.
3. Gadgil M. and Guha R. (1997) This Fissured Land, Oxford, New Delhi.
4. Guha R. (2000) Environmentalism: A Global History, Oxford, New Delhi.
5. Kamala S. and Singh U.K. (eds.) (2008) Towards Legal Literacy: An Introduction to Law in India, Oxford, New Delhi.
6. Sands P. (2002) Principles of International Environmental Law, 2nd ed, Cambridge.
7. Singh C. (1986) Common Property and Common Poverty, Oxford, New Delhi.
8. Upadhyay S. and Upadhyay V. (2002) Hand Book on Environmental Law- Forest Laws, Wildlife Laws and the Environment; Vols. I, II and III, Lexis Nexis-Butterworths-India, New Delhi.
9. Judith, P. 1999. Handbook of Environmental Impact Assessment. Blackwell Science.
10. Marriott, B. 1997. Environmental Impact Assessment: A Practical Guide. McGraw-Hill, New York, USA.
11. Naseem, M. 2011. Environmental Law in India Mohammad. Kluwer Law International.
12. Venkat, A. 2011. Environmental Law and Policy. PHI Learning Private Ltd.
13. Rosencranz A, Divan S, Noble ML. 2001. Environmental law and policy in India. Tripathi.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Environmental Impact Assessment and Regulatory Framework		**Course Code : SEN51202**
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO 1	Explain the major principles of environmental impact assessment in India.	**PO2, PO4, PO5, PO8, PO9, PSO1, PSO3, PSO4**

CO 2	Discuss the implications of current jurisdictional and institutional arrangements in relation to environmental impact assessment	**PO1, PO2, PO3, PO4, PO5, PO 6, PO7, PSO1, PSO3, PSO4**
CO 3	Construct and deconstruct different case studies/examples of EIA in practice	**PO1, PO2, PO4, PO6, PO7, PO8, PSO2, PSO3**
CO 4	Understand the origins and sources of environmental laws, and understand how and by whom environmental laws are made and interpreted.	**PO1, PO2, PO4, PO6, PO7, PSO1, PSO4**
CO 5	Critically analyse environmental laws within various contexts and to evaluate laws against procedural and substantive criteria.	**PO2, PO4, PO5, PO7, PSO2**

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	Internal	Attendance	Mid Term	End Term
Weightage (%)	**30**	**10**	**20**	**40**

		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
SEN52102	**Environmental Impact Assessment and Regulatory Framework**	2	3	3	3	3	2	3	3	3	2	2	2	3	1

1 = weakly mapped

2 = moderately mapped

3 = strongly mapped

Model Question Paper

Name: **Enrolment No:**	ADAMAS UNIVERSITY PURSUE EXCELLENCE

Course: SEN51202 – Environmental Impact Assessment and Regulatory Framework
Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**
Semester: Odd 2020-21 **Max. Marks: 40**
Total no. of questions: 12

Instructions:
Attempt all (five) questions from **Section A** (each carrying 2 marks); any **Four Questions** from **Section B** (each carrying 5 marks); any one question from **Section C** (carrying 10 marks)**.**

Section A (Attempt **all the questions)**			
1.	Mention any two importance of EIA.	**U**	**CO3**
2.	What do you mean by Category A and B vis a vis EIA in India.	**R**	**CO2**
3.	EIA is an applicant's report – Justify the statement.	**An**	**CO5**
4.	In a residential locality "A" is involved in a business of loading,unloading and stocking of fodder. It has become health hazard to the residents of the locality, as the whole atmosphere was polluted due to dust particles of the fodder. "B" a resident of the locality approaches you. Advise him.	**Ap**	**CO1**
5.	Define "Reserved forest under Forest Conservation Act".	**U**	**CO4**
Section B (Attempt any **four questions)**			
6.	Enlist the different agencies for EIA and explain their roles.	**U**	**CO3**
7.	Explain the term; (i) TOR (ii) EAC (iii) SEIAA. What is Baseline study? What is its importance in EIA?	**R**	**CO5**
8.	In one of the villages there was no "door to door" or community collection of solid waste. The Muncipal solid waste was dumped in open area mainly in the outskirts of the village. Due to dumping of the waste on open land the ground water of some area was contaminated. i) To which authority the aggrieved residents can complaint against the contamination. ii) Under which legal frame the action will be taken against the culprit ? iii) What action will be carried out against the defaulters ?	**E**	**CO2**
9.	Enumerate the powers of central government to take measures for protection and improvement of environment under EPA 1986.	**R**	**CO1**
10.	In one of the cases, the lease was granted to an area for Areca nut plantation in the past. The said area was surrounded by thick forest. The lease was not renewed and with the growth of the plantation the increasing activities of people and vehicles started damaging the thick forest. i) How non renewal of lease relate to the damaging of forest environment ? ii) What is the role of concerning state in this matter ?	**C**	**CO4**

	iii) Cite similar case law..		
Section C (Attempt any **one question)**			
11.	Explain the different types of checklist methods for EIA. Define EIS justifying the statement "EIS is the conclusion of EIA".	**R**	**CO3**
12.	Discuss fully the procedure followed in collection of effluent samples, their analysis, submission of analysis report and actions taken defaultersunder EPA 986.	**Ap**	**CO5**

SEN52104	Elective Paper II Industrial pollution prevention and clean technologies	L	T	P	C
Version 1.0	**Contact Hours – 30**	2	0	0	2
Pre-requisites/Exposure	Basic physics, chemistry, and mathematics.				
Co-requisites	-				

Course Objectives

1. Define pollution and its global implications.
2. Classify various pollutants and their emission standards.
3. To describe and explain methods employed to measure different pollutants.
4. To illustrate atmospheric stability classes via atmospheric dispersion modelling.
5. To demonstrate the air pollution control devices.
6. To determine the source, effects and control of pollution.
7. To measure and control of radiation relating disposal of radioactive waste, hazardous waste, electronic waste etc.

Course Outcomes

On completion of this course, the students will be able to

CO1.	Classify different types of pollutants, their sources and effects on the environment.
CO2.	Demonstrate sampling techniques and real-time measurements of different pollutants.
CO3.	Demonstrate the principles of pollution control devices.
CO4.	Explain the influence of meteorological phenomena on air quality and atmospheric dispersion modelling.
CO5.	Describe the source of noise pollution, their effects on the auditory system and health and to measure noise pollution.
CO6.	Interpret radiation pollution with handling and disposal of radioactive wastes.
CO7.	Apply such knowledge to perform engineering calculations for simple systems
CO8.	Promote the solution of open-ended, multi-disciplinary problems typically found in industrial settings.
CO9.	Understand the dynamics of disposal strategies of various pollutants.

Course Description: This is a specialise course to elucidate latest developments in pollution management practices in diverse pollution sources including industries. Selected case studies are chosen to reinforce key concepts and issues. The course concludes with a brief discussion on pollution issues in small-scale industries and industrial estate planning. This course aims to advance students' abilities in applying and evaluating the physico-chemical treatment processes for industrial wastewater pollution control, air pollution, and contaminated groundwater remediation, as well as to expose the student to other less frequent pollution sources, such as noise pollution. Specific modules are included for various types of solid wastes also.

Detailed syllabus

Unit I: Industrial Pollution Control **(10L)**

Assessment of the current status of the technologies for the referred industries in the World and in India, the latest technologies and available technological options, the economic aspects of the various technologies along with their feasibilities which leads to the preferred options. Case studies of cement industry, Integrated iron and steel plants, thermal power plants, aluminium smelters, zinc smelters, copper smelters, foundries, tanneries, textile industries, petrochemical industries, pharmaceutical industries. Pollutants like dust, Carbon monoxide, Sulphur dioxide, Hydrogen sulphide, Ammonia, Furfural alcohol, Toluene, Benzene, methanol, Xylene, Phenol, Formaldehyde, Cyanide, Iso-cyanates, Dimethyl – ethyl amine, Acrolein and Triethylamine from small industrial units and suitable control systems.

Unit II: Resource Recovery **(6L)**

4R - reduce, reuse, recycle and recover; biological processing - composting, anaerobic digestion, aerobic treatment; reductive dehalogenation; mechanical biological treatment; green techniques for waste treatment.

Unit III: Clean Technologies **(14L)**

Increase in energy efficiency: cogeneration, motor system optimization, oxy-fuel firing, isothermal melting process, energy efficient fume hoods, compact fluorescent lights (CFLs), motion detection lighting, or programmable thermostats). Green House Gas (GHG) emissions reduction: carbon capture and storage (CCS) technologies, purchase and use of carbon offsets, promotion and/ or subsidy of alternative forms of transportation for employees, such as carpools, fuel efficient vehicles, and mass transit, methane emissions reduction and/or reuse). Pollution reduction and removal (Flue Gas Desulfurization (FGD) methods, catalytic or thermal destruction of NOX, Fluidized Bed Combustion, Dioxins reduction and removal methods, Thermal Oxidizers or Wet Scrubbers to neutralize chemicals or heavy metals, solvent recovery systems, Low Volatile Organic Compound (VOC) paints and sealers).

Text Books

Air Pollution Control:

• Flagan and Seinfeld, “Fundamentals of Air Pollution Engineering”

• Baumbach, “Air Quality Control”

• Davis, “Air Pollution Engineering Manual”

• Mycock, McKenna and Theodore, “Handbook of Air Pollution Control Engineering and Technology”

Water Pollution Control:

• Wastewater Engineering: Treatment and Resource Recovery, 5th Edition, Metcalf & Eddy/AECOM, George Tchobanoglous, H. David Stensel, Ryujiro Tsuchihashi, Franklin L Burton, McGraw-Hill, 2013

• Hazardous Waste Management, 2nd Edition, LaGrega, M.D., Buckingham, P.L. and Evans, J.C., McGraw-Hill or Waveland Press, Inc., 2001.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Elective Paper II Industrial pollution prevention and clean technologies **Course Code : SEN52104**		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO 1	Classify different types of pollutants, their sources and effects on the environment.	**PO2, PO4, PO5, PO8, PO9, PSO1, PSO3, PSO4**
CO 2	Demonstrate sampling techniques and real-time measurements of different pollutants.	**PO1, PO2, PO3, PO4, PO5, PO 6, PO7, PSO1, PSO3, PSO4**
CO 3	Demonstrate the principles of pollution control devices.	**PO1, PO2, PO4, PO6, PO7, PO8, PSO2, PSO3**
CO 4	Explain the influence of meteorological phenomena on air quality and atmospheric dispersion modelling.	**PO1, PO2, PO4, PO6, PO7, PSO1, PSO4**
CO 5	Describe the source of noise pollution, their effects on the auditory system and health and to measure noise pollution.	**PO2, PO4, PO5, PO7, PSO2**
CO 6	Interpret radiation pollution with handling and disposal of radioactive wastes.	**PO2, PO4, PO5, PO7, PSO1, PSO2**
CO 7	Apply such knowledge to perform engineering calculations for simple systems	**PO2, PO4, PO5, PO7, PSO1, PSO2**
CO 8	Promote the solution of open-ended, multi-disciplinary problems typically found in industrial settings.	**PO2, PO4, PO6, PO7, PO8, PSO1, PSO3, PSO5**
CO 9	Understand the dynamics of disposal strategies of various pollutants.	**PO1, PO3, PO4, PO6, PO7, PO9, PSO1, PSO2**

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	**Internal**	**Attendance**	**Mid Term**	**End Term**
Weightage (%)	**30**	**10**	**20**	**40**

		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource management, and loss of biodiversity.	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental issues.	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
SEN52104	**Elective Paper II Industrial pollution prevention and clean technologies**	2	3	3	3	3	2	3	3	3	2	2	2	3	1

1 = weakly mapped

2 = moderately mapped

3 = strongly mapped

Model Question Paper

Name: **Enrolment No:**	

Course: SEN52104 – Elective Paper II Industrial pollution prevention and clean technologies
Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**
Semester: Odd 2020-21 **Max. Marks: 40**
Total no. of questions: 12

Instructions:
Attempt all (five) questions from **Section A** (each carrying 2 marks); any **Four Questions** from **Section B** (each carrying 5 marks); any one question from **Section C** (carrying 10 marks)**.**

Section A (Attempt **all the questions)**			
1.	Explain inversion. Elaborate on how inversion will affect the dispersion of pollutants.	**R**	**CO4**
2.	Discuss any two aerobic methods available for sludge treatment.	**R**	**CO6**
3.	Describe working principle of scrubber.	**R**	**CO8**
4.	Write a note on aerated lagoon.	**U**	**CO3**
5.	What do you mean by isokinetic sampling?	**U**	**CO2**
Section B (Attempt any **four questions)**			
6.	Explain the methods of heat stress protection in industrial environment.	**An**	**CO1**
7.	Write short notes on odour control techniques in chemical industries.	**Ap**	**CO3**
8.	Explain in detail Multiple Effect Evaporator.	**E**	**CO1**
9.	Briefly explain the different atmospheric stability classes.	**R**	**CO4**
10.	What are the measurement techniques of odour pollution?	**R**	**CO8**
Section C (Attempt any **one question)**			
11.	Discuss the waste water treatment scheme used in sugar industry.	**E**	**CO1**
12.	With the help of a neat sketch explain the principle, construction and working of a Cyclone Separator.	**Ap**	**CO1**

SEN52106	Design for water and wastewater systems	L	T	P	C
Version 1.0	Contact Hours – 30	2	0	0	2
Pre-requisites/Exposure	Basic physics, chemistry, and mathematics.				
Co-requisites	-				

Course Objectives

1. To illustrate physical and chemical parameters of water quality and water pollution.
2. To interpret different water quality standards.
3. To describe various water purification processes in natural streams.
4. To analyse the metabolic processes in response to biodegradable organic waste in stream.
5. To classify various physical, chemical and biological water treatment processes.
6. To categorize wastewater treatment processes and wastewater characterization.

Course Outcomes

On completion of this course, the students will be able to

CO1.	Classify different types of water pollutants, their sources and effects on the environment.
CO2.	Demonstrate water sampling techniques and measurements of different water quality parameters.
CO3.	Categorize different water quality standards.
CO4.	Determine various physical, chemical and biological water treatment processes.
CO5.	Understand the dynamics of metabolic processes of biodegradable organic waste in stream.
CO6.	Demonstrate engineered systems associated with wastewater treatment processes.

Course Description: Water pollution is a state of deviation from the pure condition, whereby its normal function and properties are affected. This course is depicts a knowledge of aquatic environmental chemistry which is the key to the understanding of water pollution and its control. Water pollution can be best considered in the perspective of possible pollutant cycles throughout the environment. The course focuses the sampling and analysis of various physico-chemical parameters of water quality and the water quality standards according to their sources and uses. Besides physical, chemical and biological water treatments processes, demonstration of the engineered treatment processes of wastewater management most of which take place in industries are other important aspects of the course.

Detailed syllabus

Unit I: Fundamentals of Hydraulics **(5L)**

Basic properties of water; Determination of hydrostatic forces; Kinematics of flow; Potential flow; Continuity, Energy and Momentum principles; Open channel flow; Uniform and gradually varied flows; Dimensional analysis; Hydraulic similitude and Modelling; Flow in pipes and Pipe networks; Hydraulics machines; Pumps and Turbines.

Unit II: Water and Wastewater Engineering **(5L)**

General requirement for water supply, population forecasting and water demand, sources, intake, pumping and transportation of water; Physical, chemical and biological characteristics of water and their significance, Water quality criteria, Water borne diseases, Natural purification of water sources. Engineered systems for water treatment: aeration, sedimentation, softening, coagulation, filtration, adsorption, ion exchange, and disinfection. Generation and collection of wastewater, quantities of sanitary wastes and storm water. Design of sewerage system Primary, secondary and tertiary treatment of wastewater; Wastewater disposal standards. Basics of microbiology. Biological wastewater treatment systems: Aerobic processes - activated sludge process and its modifications, trickling filter, RBC, Anaerobic Processes- conventional anaerobic digester, High rate and hybrid anaerobic reactors. Sludge digestion and handling. Disposal of effluent and sludge Design problems on water and wastewater treatment units and sludge digestion.

Unit III: Water Treatment and Supply **(10L)**

Water requirements, Types of water demands, Water demand forecasting, Surface water and ground water sources, Water quality and drinking water standards, Water treatment systems, Physico-chemical processes, Sedimentation, Coagulation, Flocculation, Granular media filtration, Disinfection, Water softening, Adsorption and ion exchange processes, Desalination, Membrane filtration, Treatment of specific contaminants: Fluoride, Nitra and Arsenic, Water supply schemes, Determination of reservoir capacity, Gravitational, pumping and combined water supply schemes, Water-lifting arrangements, Distribution reservoirs and service storage, Pumping and design considerations for pumps, Design and hydraulic analysis of water distribution system, Distribution system components, Aqueducts, Hydraulics of conduits, Appurtenances and valves, water pipes, Storage tanks, Optimization of pipe network systems, Planning of urban and metropolitan water supply project and its implementation

Unit IV: Advanced Wastewater Treatment **(10L)**

Wastewater- Sources, nature and characteristics, Population equivalent, Municipal wastewater collection, Systems of sanitation and water carriage, Estimation of wastewater flows and variation in wastewater flow, Estimation of storm water runoff, Process Flow sheets, Reactor Analysis, Unit operations and processes, Theory and Design of biological treatment processes, Aerobic treatment such as activated sludge process, Extended Aeration, oxidation ditches, Biofilm Processes: trickling filters, biotowers, MBBR and Natural Processes: Membrane Bio Reactor Process Description : Membrane Bioreactor with Membrane Module Submerged in the Bioreactor, Membrane Bioreactor with Membrane Module Situated Outside the Bioreactor MBR System Features Membrane Module Design Considerations Process Applications : Industrial Wastewater Treatment, Municipal Wastewater stabilization ponds, aerated lagoon, Anaerobic treatment: upflow anaerobic sludge blanket reactor, Anaerobic Filters, sludge treatment and disposal, Design of a wastewater treatment plant, On Site collection and Disposal, pit latrines, Compositing privy, Septic Tanks and Aqua privy.

Text Books

1. De A.K., Environmental Chemistry, New Age International Publishers.
2. Manahan, S.E., Environmental Chemistry, Lewis Publishers.
3. Natusch, D.F.S. and Hopke, P.K., Analytical Aspects of Environmental Chemistry, John Wiley & sons.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Design for water and wastewater systems Course Code : SEN52106		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO 1	Classify different types of water pollutants, their sources and effects on the environment.	**PO 1, PO2, PO4, PO5, PO7, PO8, PO9, PSO1, PSO2, PSO5**
CO 2	Demonstrate water sampling techniques and measurements of different water quality parameters.	**PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO 8, PO9, PSO1, PSO3, PSO4**
CO 3	Categorize different water quality standards.	**PO2, PO3, PO5, PO7, PSO1, PSO4, PSO5**
CO 4	Determine various physical, chemical and biological water treatment processes.	**PO1, PO2, PO4, PO6, PO7, PO8, PSO1, PSO4, PSO5**
CO 5	Understand the dynamics of metabolic processes of biodegradable organic waste in stream.	**PO2, PO4, PO5, PO7, PSO 1, PSO2, PSO4**
CO 6	Demonstrate engineered systems associated with wastewater treatment processes.	**PO2, PO3, PO6, PO7, PSO1, PSO3, PSO4, PSO5**

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	**Internal**	**Attendance**	**Mid Term**	**End Term**
Weightage (%)	**30**	**10**	**20**	**40**

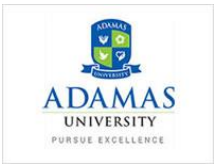
		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource management, and loss of biodiversity.	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental issues.	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
SEN52106	**Design for water and wastewater systems**	3	3	3	3	3	3	3	3	3	2	2	2	3	2

1 = weakly mapped

2 = moderately mapped

3 = strongly mapped

Model Question Paper

Name: **Enrolment No:**	

Course: SEN52106 – Design for water and wastewater systems

Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**
Semester: Odd 2020-21 **Max. Marks: 40**
Total no. of questions: 12

Instructions:
Attempt all (five) questions from **Section A** (each carrying 2 marks); any **Four Questions** from **Section B** (each carrying 5 marks); any one question from **Section C** (carrying 10 marks)**.**

Section A (Attempt **all the questions)**			
1.	What is COD?	**U**	**CO2**
2.	What is fluorosis?	**R**	**CO1**
3.	What do you mean by Oxygen Sag Curve analysis?	**An**	**CO5**
4.	What are the physical parameters of water quality?	**Ap**	**CO2**
5.	What is DO?	**R**	**CO2**
Section B (Attempt any **four questions)**			
6.	What are the aerobic treatment processes? Discuss the distinguishing features of Activated Sludge Process. (2+3=5)	**R**	**CO6**
7.	Discuss some of the advantages of physico-chemical treatment of sewage as opposed to biological treatment. What are the relative disadvantages? (3+2=5)	**U**	**CO6**
8.	Give an account of the chemical treatment processes of water.	**Ap**	**CO4**
9.	Briefly describe the secondary treatment process of wastewater.	**An**	**CO6**
10.	Compare the advantages of aerobic and anaerobic processes.	**E**	**CO6**
Section C (Attempt any **one question)**			
11.	Explain the environmental chemistry of (a) Hg and (b) As, in an aquatic ecosystem.	**U**	**CO1**
12.	Describe methods for the estimation of the following parameters in water sample: (a) Nitrate and Nitrite (b) Phosphate (c) Biological Oxygen Demand (d) Hardness (e) Chromium (5x2=10)	**R**	**CO2**

SEN52108	Elective III Environmental Economics, Ethics and Policies	L	T	P	C
Version 1.0	**Contact Hours – 30**	2	0	0	2
Pre-requisites/Exposure	Basic environmental science				
Co-requisites	-				

Course Objectives

1. Appreciate the purpose and role of EIA in the decision-making process.
2. Students will be able to get basic knowledge of environment, pollution and various principles.
3. To explain the role of law, policy and institutions in the conservation and management of natural resources as well as pollution control
4. To introduce to the students, the dynamics between environment and economics.
5. To equip the students with the skills needed for interpreting laws, policies and judicial decisions
6. Students will be able to get the knowledge about Constitutional provisions for the protection of environment.
7. Students will learn about the legal provisions of pollution.
8. Students will get the knowledge about the Environment (protection) Act, powers of central government and state government to make laws and Environment Tribunals

Course Outcomes

On completion of this course, the students will be able to

CO1.	Demonstrate an active understanding of the following elements of economic theory as it relates to natural resource and environmental economics.
CO2.	Demonstrate a basic knowledge of the role of markets and market failure with regards to the allocation of natural resources and environmental amenities.
CO3.	Develop a basic understanding of the effects and relative merits of public environmental policy efforts, including cap-and-trade schemes, Pigovian taxes, regulation, and public ownership and/or management.
CO4.	Understand the origins and sources of environmental laws, and understand how and by whom environmental laws are made and interpreted.
CO5.	Comprehend the interplay between politics, policy, science and values in environmental law.

Course Description: This course studies the application of economic analysis to the management of the environmental and natural resources. We will consider the role of economic theory in understanding and solving environmental and resource problems and discuss empirical examinations of the theory. Policy implications will be addressed with particular attention paid to analysing practical applications of the theories in different social, economic and political environments. A key assessment component will involve students undertaking a practical analysis of a resource or environmental policy of relevance to themselves or country of origin. Topics that may be covered include: air and water pollution, sustainability, renewable and non-renewable resource management, and the impact of trade.. Law and policy plays a major role in the conservation and management of natural resources as well as pollution

control. This course intends to introduce the students to the vast field of Environmental Law and Policy. The course would be divided into three broad areas. The first part would cover the basic concepts and principles of Environmental Law. This would include judicial precedents, which now forms an essential part of environmental jurisprudence. The second part would be divided into specific introductory modules on forests and wildlife including bio-diversity related laws; Air and Water related laws including mega projects and marine laws; and laws relating to hazardous substances. The third part would discuss the developments at the international level in the field of environmental law. At the end of the course it is expected that the students would be familiar with the overall Environmental Law and Policy regime of the country as well as its international obligations. It is expected that the case studies would equip them with basic knowledge and skills to understand environmental law issues.

Detailed syllabus

Unit I: Environmental Economics, Ethics and Policies **(20L)**

The Economy and the Environment: Two Parts of a Whole – Interlinkages between the economy and the environment. Micro Foundations of Environmental Economics - Theory of Public goods, Externalities and Market failure – The Problem of Social Cost - Design of Environmental Policy. Economic Instruments for Environmental Protection: Command & Control versus Incentives and Subsidies - Available Policy Options - Effectiveness of these instruments, International Comparisons. Economics of Natural Resource Exploitation – Renewable and Non-Renewable Resources – Methods of valuation of Environmental Costs and Benefits. Economic Growth and the Environment: Environmental Kuznets' curve, Foreign Direct Investment Inflow and the Environmental quality. Economic Rent Theory, Hotelling's Rule. Sustainable Development: Concept of and issues in Sustainable Development, Strategic Planning for Sustainable Development, Economic reforms and sustainable development. Introduction to Indian Economy. Climate Change and India: Vulnerability of regions and populations – Adaptation options.

Unit II: Laws, Ethics and Policies **(25L)**

International Environmental Laws: Evolution and development of International Environmental laws with reference to Stockholm Conference, Nairobi Declaration, Rio Conference, Rio+5 and the Rio+10, etc. Global environmental issues and International laws: to control Global warming, Ozone depletion, Acid rains, hazardous waste, CITES etc. Role of UN authorities in protection of Global Environment, Multinational authorities and agreements, future of International laws. Introduction to the Indian Constitution, Environmental laws in India: Environmental Policy and laws. Constitutional and statutory laws in India: Doctrine Principles of State Policy, Fundamental Duties and Fundamental Rights and Panchayat Raj System. Statutory protection of the Human Environment: such as Indian Penal Code, Factories Act, Motor Vehicle Act, Hazardous Waste legislation for pollution abatement. Anti Pollution Acts: The water Act. 1974. The Air Act 1981. The Environment Protection Act 1986 Objectives of the Anti-pollution Acts. Institutional mechanism created under these acts and role and contribution in combining environmental pollution. The role of courts Equity Environment versus Development: Importance of critical review of plan with respect to local, regional &

immediate & long term gains & Effect of Development. Comparison between a. Exploitation and safe guard for conservation, b. Rate of utilization and regeneration, c. Natural and manmade growth, d. Survival need of mankind and protection of environment, Integration of development with carrying capacity of environment. Case study of current issue Requirements of Rule 14 for Environmental Audit under Environmental protection Act 1986 Rule & regulations & guidelines given for disposal of hazardous waste, municipal solid waste & bio-medical waste National Environmental Policy: National Policy on EIA and Regulatory Framework: Rule & regulations of central & state Government and Central & State pollution control boards for Safeguard for Environmental Protection Sustainable Development: Definition and concepts of sustainable development, Integration of: a. Economic, Social and Environmental sustainability, b. Biodiversity and c. Availability of natural resources in development. Critical review of drawbacks in traditional (base on economics) evaluation of development, Cost benefit analysis. Introduction of Ecological growth factor similar to economic growth factor for sustainable development.

Text Books

1. Environmental Law and Policy in India: Shyam Divan: Armin Rosencranz
2. Divan S. and Rosencranz A. (2005) Environmental Law and Policy in India, 2nd ed., Oxford, New Delhi
3. Leelakrishnan P. (2008) Environmental Law in India, 3rd ed., Lexis Nexis, India
4. Perman R., Y. Ma, M. Common, D. Maddison, and J. McGilvray (2011) Natural Resource and Environmental Economics. Fourth Edition, Pearson-Addison Wesley.
5. Tietenberg, Tom. Environmental and Natural Resource Economics, Latest Ed. New York: Harper Collins Publishers Inc.

Reference books

1. Pearce, David W. and Jeremy J. Warford. World Without End: Economics, Environment and Sustainable Development.
2. Barde, Jean-Phillipe and David W. Pearce. Valueing the Environment: Six Case Studies.
3. Doern, G. Bruce (editor). Getting it Green, Case Studies in Canadian Environmental Regulation. C.D. Howe Institute.
4. Desai A. (2002) Environmental Jurisprudence, 2nd ed., Modern Law House, Allahabad.
5. Gadgil M. and Guha R. (1995) Ecology and Equity, Oxford, New Delhi.
6. Gadgil M. and Guha R. (1997) This Fissured Land, Oxford, New Delhi.
7. Guha R. (2000) Environmentalism: A Global History, Oxford, New Delhi.
8. Kamala S. and Singh U.K. (eds.) (2008) Towards Legal Literacy: An Introduction to Law in India, Oxford, New Delhi.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Elective III Environmental Economics, Ethics and Policies Course Code : SEN52108		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO 1	Demonstrate an active understanding of the following elements of economic theory as it relates to natural resource and environmental economics.	**PO2, PO4, PO5, PO8, PO9, PSO1, PSO3, PSO4**
CO 2	Demonstrate a basic knowledge of the role of markets and market failure with regards to the allocation of natural resources and environmental amenities.	**PO1, PO2, PO3, PO4, PO5, PO 6, PO7, PSO1, PSO3, PSO4**
CO 3	Develop a basic understanding of the effects and relative merits of public environmental policy efforts, including cap-and-trade schemes, Pigovian taxes, regulation, and public ownership and/or management.	**PO1, PO2, PO4, PO6, PO7, PO8, PSO2, PSO3**
CO 4	Understand the origins and sources of environmental laws, and understand how and by whom environmental laws are made and interpreted.	**PO1, PO2, PO4, PO6, PO7, PSO1, PSO4**
CO 5	Comprehend the interplay between politics, policy, science and values in environmental law.	**PO2, PO4, PO5, PO7, PSO2**

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	**Internal**	**Attendance**	**Mid Term**	**End Term**
Weightage (%)	**30**	**10**	**20**	**40**

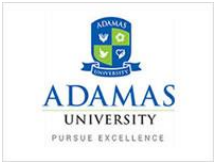
		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
SEN52108	**Elective III Environmental Economics, Ethics and Policies**	2	3	3	3	3	2	3	3	3	2	2	2	3	1

1 = weakly mapped

2 = moderately mapped

3 = strongly mapped

Model Question Paper

Name: **Enrolment No:**	

Course: SEN52108 – Elective III Environmental Economics, Ethics and Policies
Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**
Semester: Odd 2020-21 **Max. Marks: 40**
Total no. of questions: 12

Instructions:
Attempt all (five) questions from **Section A** (each carrying 2 marks); any **Four Questions** from **Section B** (each carrying 5 marks); any one question from **Section C** (carrying 10 marks)**.**

Section A (Attempt **all the questions)**			
1.	'Economic growth and environmental balance do not go together' Do you agree?	**U**	**CO3**
2.	Examine Coase theorem.	**R**	**CO2**
3.	How do you treat environmental quality as a public good?	**An**	**CO5**
4.	In a residential locality "A" is involved in a business of loading,unloading and stocking of fodder. It has become health hazard to the residents of the locality, as the whole atmosphere was polluted due to dust particles of the fodder. "B" a resident of the locality approaches you. Advise him.	**Ap**	**CO1**
5.	Define "Reserved forest under Forest Conservation Act".	**U**	**CO4**
Section B (Attempt any **four questions)**			
6.	Climate change has turned out to be one of the serious environmental challenges the world is facing today. Provide a brief account on the science (process) of climate change, its effects on economy and society, and the complexities involve in dealing with this rapidly emerging challenge especially from the perspectives of economics.	**U**	**CO2**
7.	Outline the key approaches of environmental economics and ecological economics. Do you see the two approaches as competitive or complementary? Justify your answer.	**R**	**CO4**
8.	Write a note on sustainability criterion by applying the "Hartwick Rule", strong sustainability, and environmental sustainability.	**E**	**CO3**
9.	Enumerate the powers of central government to take measures for protection and improvement of environment under EPA 1986.	**R**	**CO1**
10.	In one of the cases, the lease was granted to an area for Areca nut plantation in the past. The said area was surrounded by thick forest. The lease was not renewed and with the growth of the plantation the increasing activities of people and vehicles started damaging the thick forest. i) How non renewal of lease relate to the damaging of forest environment ? ii) What is the role of concerning state in this matter ? iii) Cite similar case law..	**C**	**CO5**
Section C (Attempt any **one question)**			

11.	(a) Using the framework of efficient property right structure explain how the presence of "externalities" is a source of market failure, and draw important conclusions about market allocation of commodities causing pollution externalities. (b) Illustrate the different improperly designed property rights that exist in an economy? (5+5)	**R**	**CO2**
12.	Discuss fully the procedure followed in collection of effluent samples, their analysis, submission of analysis report and actions taken defaulters under EPA 986.	**Ap**	**CO5**

SEN52110	Elective III Occupational health safety and Environmental Management	L	T	P	C
Version 1.0	**Contact Hours – 30**	2	0	0	2
Pre-requisites/Exposure	Basic environmental science				
Co-requisites	-				

Course Objectives

1. Students will be able to recognize and evaluate occupational safety and health hazards in the workplace.
2. Determine appropriate hazard controls following the hierarchy of controls.
3. Students will furthermore be able to analyse the effects of workplace exposures, injuries and illnesses, fatalities and the methods to prevent incidents using the hierarchy of controls, effective safety and health management systems and task oriented training.
4. Master core concepts and methods from ecological and physical sciences and their application in environmental problem solving.
5. Master core concepts and methods from economic, political, and social analysis as they pertain to the design and evaluation of environmental policies and institutions.

Course Outcomes

On completion of this course, the students will be able to

CO1.	Evaluate workplace to determine the existence of occupational safety and health hazards
CO2.	Identify relevant regulatory and national consensus standards along with best practices that are applicable.
CO3.	Select appropriate control methodologies based on the hierarchy of controls.
CO4.	Analyse injury and illness data for trends.
CO5.	Affect/manage change by advancing OH&S principles within management systems, cultures, practices, and priorities.
CO6.	Apply basic adult learning and assessment principles in the design, development and delivery of training and information for differing levels within the workplace.
CO7.	Use a range of effective communication skills and methods to clearly and briefly convey regulatory and technical information and data to designated audiences.
CO8.	Provide definitions of environment, management, systems and organisations in relation to environmental management
CO9.	Understand the usefulness of systems thinking in relation to environmental management in organisations
CO10	explain how environmental management can be used as environmental protection and how organisations can define and manage risk.

Course Description: This course examines occupational safety and health practices needed to address occupational safety and health issues in the workplace. Students will utilize regulatory standards as a guide to apply policies, procedures, standards and occupational safety and health principles. Industry recognized best practices, origin of the standards, the process and rules of inspections, citations and penalties and polices will be covered. In this course you will investigate the complex relationships between economic, social and environmental systems and learn how local actions can have global effects. You will recognise the importance of

preserving biodiversity and that healthy ecosystems are the foundation of economic and societal well-being. You will also become familiar with environmental and natural resource management objectives at different scales and in different sectors and the management practices relevant to achieving them.

Detailed syllabus

Unit I: Introduction : **(5L)**

Importance of environmental safety and Occupational Health Hazards in industry; Safety and Health training; Characteristics of Occupational illness, Ethical Considerations; Risk assessment: Risk Assessment Basics, Exposure Assessment, Dose–Response Assessment, Comparative Risk Analysis, Risk Communication; Concept of healthy and safe workplace

Unit II: Occupational Health Studies: **(10 L)**

The appropriate measures to control the hazards associated with work related ill health including: (a) Chemical safety (b)biological hazards (c) Noise (d) Radiation (e) vibration; Chemical safety: classifications of chemicals, purpose of the chemical classifications, routes of entry to human body, defence mechanism of human body, Different air pollutants in industries, Effect of different gases and particulate matter, acid fumes ,smoke, fog on human health; Biological hazards: various types of biological agent, assessment of biological and control of biological agents at workplaces; Industrial Hygiene; Ergonomics – principals and its application, Ergonomics Hazards- Musculoskeletal Disorders and Cumulative Trauma Disorders; Personal Protective equipment (PPE)

Unit III: Electrical hazards and safety in construction industry **(5L)**

Safe limits of amperages, voltages, distance from lines, etc., Joints and connections, Overload and Short circuit protection, Earthing standards and earth fault protection; Protection against voltage fluctuations, Effects of shock on human body Hazards from Borrowed neutral; Electrical equipment in hazardous atmosphere, Criteria in their selection, installation, maintenance and use, Control of hazards due to static electricity, Introduction of Construction industry: scaffolding and working plat form, welding and cutting, excavation Work, concreting and cementing work,.

Unit IV: Health Safety and Environmental management and its implementation **(10L)**

Organisations involved in developing occupational health and safety management systems: International organisation for Standardisation, British Standards Institution, OSHA 18001; Concept and Significance of ISO 14001:2015 and ISO 45001:2018; Integrated Management System -Need for integration of Safety- Health & Environment – Role of top management – Role of National Government & International bodies in formulating framework for regulations of safety.

Text Books

1. Haldar, S.K., Industrial and Occupational Health, CBS.
2. Parekh, R., and Moti, S., BOHS - Basic Occupational Health Services, Vakils, Feffer & Simons Pvt. Ltd.
3. Jain, R.K., and Rao, S.S., Industrial Safety, Health and Environment Management Systems, Khanna Publishers.
4. Thomas, J., Environmental Management: Text and Cases, Pearson.
5. Sankar, A.R.N., Environmental Management, Oxford University Press.

Reference books

1. Creek's Occupational Therapy and Mental Health (Occupational Therapy Essentials), Eds. W. Byrant, J. Fieldhouse, K. Bannigan, Churchill Livingstone Publishers.
2. Goetsch, D.L., Occupational Safety and Health: for Technologists, Engineers, and Managers, Pearson.
3. Sharma, S.C. and Kumar, V., Safety, Occupational Health and Environmental Management in Construction, Khanna Publishers.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Elective III Occupational health safety and Environmental Management **Course Code : SEN52110**		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO 1	Evaluate workplace to determine the existence of occupational safety and health hazards	**PO2, PO4, PO5, PO8, PO9, PSO1, PSO3, PSO4**
CO 2	Identify relevant regulatory and national consensus standards along with best practices that are applicable.	**PO1, PO2, PO3, PO4, PO5, PO 6, PO7, PSO1, PSO3, PSO4**
CO 3	Select appropriate control methodologies based on the hierarchy of controls.	**PO1, PO2, PO4, PO6, PO7, PO8, PSO2, PSO3**
CO 4	Analyse injury and illness data for trends.	**PO1, PO2, PO4, PO6, PO7, PSO1, PSO4**
CO 5	Affect/manage change by advancing OH&S principles within management systems, cultures, practices, and priorities.	**PO2, PO4, PO5, PO7, PSO2**
CO 6	Apply basic adult learning and assessment principles in the design, development and delivery of training and information for differing levels within the workplace.	**PO2, PO4, PO5, PO7, PSO1, PSO2**
CO 7	Use a range of effective communication skills and methods to clearly and briefly convey regulatory and technical information and data to designated audiences.	**PO2, PO4, PO5, PO7, PSO1, PSO2**
CO 8	Provide definitions of environment, management, systems and organisations in relation to environmental management	**PO2, PO4, PO5, PO7, PSO1, PSO2**
CO 9	Understand the usefulness of systems thinking in relation to environmental management in organisations	**PO2, PO4, PO5, PO7, PSO1, PSO2**
CO10	explain how environmental management can be used as environmental protection and how organisations can define and manage risk.	**PO2, PO4, PO5, PO7, PSO1, PSO2**

		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
SEN52110	**Elective III Occupational health safety and Environmental Management**	2	3	3	3	3	2	3	3	3	2	2	2	3	1

1 = weakly mapped
2 = moderately mapped
3 = strongly mapped

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	Internal	Attendance	Mid Term	End Term
Weightage (%)	30	10	20	40

Model Question Paper

Name: **Enrolment No:**	ADAMAS UNIVERSITY PURSUE EXCELLENCE

Course: SEN52110 – Elective III Occupational health safety and Environmental Management
Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**
Semester: Odd 2020-21 **Max. Marks: 40**
Total no. of questions: 12

Instructions:
Attempt all (five) questions from **Section A** (each carrying 2 marks); any **Four Questions** from **Section B** (each carrying 5 marks); any one question from **Section C** (carrying 10 marks)**.**

Section A (Attempt **all the questions)**			
1.	Discuss the concept of safety.	**U**	**CO1**
2.	Name the various occupational diseases caused by metals, dusts, fumes and chemical compounds.	**R**	**CO4**
3.	Enlist the types of emergency and define any one of them.	**An**	**CO5**
4.	What do you mean by the term QRA?	**Ap**	**CO10**
5.	What are the five ‘E’s of accident prevention.	**U**	**CO4**
Section B (Attempt any **four questions)**			
6.	Discuss various TLVs. Explain classification of occupational health hazards	**U**	**CO7**
7.	What do you mean by the terms VCE and BLEVE?.	**R**	**CO8**
8.	Discuss in detail route of entry of toxic material into human body.	**E**	**CO9**
9.	Draw a neat sketch of pyramid of fire and explain.	**R**	**CO2**
10.	Discuss the guide words used for hazard and operability (HAZOP) study	**C**	**CO3**
Section C (Attempt any **one question)**			

11.	Enlist the seven basic elements of management functions. With the help of examples, give application of ergonomics for safety and health	**R**	**CO5**
12.	Explain the main objectives of major hazard control system. Discuss safety in construction industry	**Ap**	**CO8**

SEN52112	Environmental Health, Biochemistry and Toxicology	L	T	P	C
Version 1.0	**Contact Hours – 30**	2	0	0	2
Pre-requisites/Exposure	Biology, Chemistry.				
Co-requisites	-				

Course Objectives

1. Understanding of basic biochemistry and structure of biomolecules.
2. Concepts of enzyme catalysis-mechanism of action and enzyme kinetics.
3. Concept of Xenobiotics and Xenobiotic induced oxidative stress.
4. Understanding ecotoxicology and various bioassay methods.
5. Importance of different biomolecules on environmental health.

Course Outcomes

On completion of this course, the students will be able to

CO1.	Understand the basic biochemistry and structure of biomolecules.
CO2.	Understand the enzyme activity and enzyme kinetics.
CO3.	Develop idea on micronutrients and their importance.
CO4.	Understand the Xenobiotic induced oxidative stress: metabolism & pathways and role of antioxidants.
CO5.	Illustrate knowledge on ecotoxicology and toxicokinetics.
CO6.	Demonstrate metabolic pathways of various carcinogens and their effects on environmental health.

Course Description: Toxicological chemistry or chemical toxicology can be best understood in the light of biochemistry which deals with the chemical properties, composition and biologically mediated processes or complex substances in living system. The course provides a general introduction to the basic chemistry, structure and enzymatic activities of bio molecules; biochemical processes of various xenobiotics. The course illustrates the concept of ecotoxicology and the modes of actions of different toxic chemicals. This course is directed towards understanding the metabolism of different carcinogens in human health and their detrimental effects on environmental health as well.

Detailed syllabus

Unit I: Biomolecules and metabolism (5L)

Basic chemistry and structure of biomolecules, Carbohydrates, Amino acids, Proteins, Lipids and Nucleic acids and their biological significance; Polypeptides; Primary, secondary and tertiary structure of proteins; Enzyme catalysis-mechanism of action, enzyme kinetics, regulation. Effects of environmental parameters of enzyme activity; Role of ATP; Glycolysis, Citric acid cycle, Glycogenesis, Glycogenolysis, Gluconeogenesis, Pentose Phosphate Pathway; Lipid metabolism; Biosynthesis of cholesterol and steroids; Fatty acid oxidation;

Electron transport chain and Oxidative phosphorylation; Transamination-Glucogenic and Ketogenic amino acids; Deamination; Conversion of amino acids to specialized products; Problems related to amino acid metabolism.

Unit II: Micronutrients (5L)

Vitamins and Minerals (macro, micro and trace elements)

Unit III: Biochemistry of Diseases (5L)

Role of lipid in cardiovascular disease; Drug metabolism; Concept of Xenobiotics; Toxic materials; Xenobiotic induced oxidative stress and role of antioxidants; Exposure, Absorption, Distribution, Metabolism and Excretion of toxicants (Phase I andPhase II reaction).Toxicants entry and fate in living system, absorption, distribution, excretion and detoxification, phase I and phase II reactions and their interrelationships, components of mixed function oxidases, substrate - cytochrome P450 interactions, isoenzymes of cytochrome P450, inducers and inhibitors of microsomal metabolic transformation, lipoxygenase, lipid peroxidation, influence of various factors on the manifestation of toxicity. Extramicrosomal enzymes and their role in detoxification.

Unit IV: Toxicity assay and ecotoxicology (10L)

Acute and chronic toxicity; Dose- Response Relationship; Whole Effluent Toxicity (WET) test; Bioassay - types, methodologies and application; Toxicokinetics and toxicokinetic analysis; Biomarkers; Bioaccumulation; Biomagnification; Bioconcentration factor; Risk assessment; Effects on population and ecosystems; Damage process and action of toxicants; Toxicity of heavy metals; Predictive toxicology.Test protocol, genetic toxicity testing and mutagenesis assays:In vitro test system, bacterial mutation test, reversion test, Ames test, fluctuation tests and eukaryotic mutation test. In vivo mammalian mutation tests, host mediated assay and dominant lethal test. DNA repair assays. Chromosome damage test. Toxicological evaluation of recombinant DNA-derived proteins.

Unit V: Environmental health (5L)

Molecular mechanism of cell death; chromosomal aberration; sister chromatid exchanges; Micronucleus and Nuclear abnormalities; DNA damage and repair mechanism; Carcinogenesis, Classification of carcinogens; Metastasis and metabolism of chemical carcinogens; cancer risk evaluation; Brief outline of cancer therapy; Teratology; Reproductive toxicity; Epidemiological issues: Goitre, Fluorosis, Arsenicosis and vector bornediseases; Diseases related to trace elements; Disease ecology: Air, water, soil; Exposure monitoring; Health monitoring; Occupational hazards; Concept of stress,Industrial Environmental Psychology; Adaptation vs Acclimatisation. Insecticides: organochlorines, anticholinesterases-organophosphates and carbamates. Fungicides, herbicides. Environmental consequences of pesticide toxicity. Biopesticides, Toxicology of food additives, animal and plant toxins. Heavy metals: arsenic, mercury, lead and cadmium. Environmental factors affecting metal toxicity.

Text Books

1. Narayanan, K.T., Safety, Health and Environment Handbook, McGraw Hill Education.
2. Gaur, H.K., Textbook of Environmental Biochemistry, Book Enclave.
3. Markandey, D.K., and Rajvaida, N., Environmental Biochemistry, APH Publishing.
4. Sharma, P.D., Environmental Biology and Toxicology, Rastogi Publications.
5. Pawar, K., and Desai, A., Environmental Biology And Toxicology, Nirali Prakashan, Educational Publishers.
6. Manahan, S.E., Fundamentals of Environmental and Toxicological Chemistry: Sustainable Science, CRC Press.

Reference books

1. Kruk, I., Environmental Toxicology and Chemistry of Oxygen Species, Springer.
2. Manahan, S.E., Environmental Chemistry, CRC Press.
3. Hamilton, E., Environmental Biochemistry, Larsen and Keller Education.
4. Ferrier, D.R., Lippincott's Illustrated Reviews Biochemistry, Wolters Kluwer India Pvt. Ltd.
5. Satake, M., Taguchi, S., Mido, Y. and Iqbal, S., Environmental Toxicology, Discovery Publishing Pvt.Ltd.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Environmental Health, Biochemistry and Toxicology Course Code : SEN52112		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO 1	Understand the basic biochemistry and structure of biomolecules.	**PO2, PO4, PO8, PSO2, PSO4**
CO 2	Understand the enzyme activity and enzyme kinetics.	**PO2, PO4, PO8, PSO2, PSO4**
CO 3	Develop idea on micronutrients and their importance.	**PO2, PO4, PO7, PO8, PSO2, PSO4**
CO 4	Understand the Xenobiotic induced oxidative stress: metabolism & pathways and role of antioxidants.	**PO1, PO2, PO4, PO7, PO9, PSO1, PSO3, PSO4**
CO 5	Illustrate knowledge on ecotoxicology and toxicokinetics.	**PO1, PO2, PO4, PO7, PO9, PSO1, PSO3, PSO4**
CO 6	Demonstrate metabolic pathways of various carcinogens and their effects on environmental health.	**PO2, PO2, PO4, PO5, PO7, PSO2, PSO3, PSO4**

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	**Internal**	**Attendance**	**Mid Term**	**End Term**
Weightage (%)	**30**	**10**	**20**	**40**

		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
SEN52112	**Environmental Health, Biochemistry and Toxicology**	2	3	2	3	2	2	3	3	3	1	2	2	3	1

1 = weakly mapped

2 = moderately mapped

3 = strongly mapped

Model Question Paper

Name: **Enrolment No:**	

Course: SEN52112 – Environmental Health, Biochemistry and Toxicology

Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**
Semester: Odd 2020-21 **Max. Marks: 40**
Total no. of questions: 12

Instructions:
Attempt all (five) questions from **Section A** (each carrying 2 marks); any **Four Questions** from **Section B** (each carrying 5 marks); any one question from **Section C** (carrying 10 marks)**.**

Section A (Attempt **all the questions)**			
1.	What is LC_{50} and LD_{50}?	**Ap**	**CO5**
2.	What is biomagnification?	**An**	**CO5**
3.	What are xenobiotics?	**R**	**CO4**
4.	Name some biomarkers present in environment.	**U**	**CO5**
5.	What is the importance of micronutrients in human body?	**U**	**CO3**
Section B (Attempt any **four questions)**			
6.	How do proteins suffer denaturations?	**An**	**CO2**
7.	Explain with examples, the effect of toxic chemicals on enzyme.	**Ap**	**CO5**
8.	Write a short note on Silicosis and Asbestosis.	**E**	**CO6**
9.	Briefly explain the biochemical pathways of glycogenesis.	**R**	**CO2**
10.	How anabolism and catabolism are distinguished?	**R**	**CO1**
Section C (Attempt any **one question)**			
11.	Illustrate with a figure how alanine, leucine and triosine would form a tripeptide.	**E**	**CO1**
12.	Explain biochemical methylation and illustrate propagation of Hg in food chain.	**Ap**	**CO6**

SEN52202	Environmental Health, Biochemistry and Toxicology (Lab)	L	T	P	C
Version 1.0	**Contact Hours – 60**	0	0	4	2
Pre-requisites/Exposure	Basic chemistry, biology and mathematics.				
Co-requisites	-				

Course Objectives

1. Understanding of basic biochemistry and structure of biomolecules.
2. Concepts of enzyme catalysis-mechanism of action and enzyme kinetics.
3. Concept of xenobiotics and xenobiotic induced oxidative stress.
4. Understanding ecotoxicology and various bioassay methods.
5. Pathways of different biomolecules in environment.

Course Outcomes

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

CO1.	Determine amino acids and estimations of proteins.
CO2.	Estimate glucose concentration by Glucose oxidase method and fructose concentration by resorcinol method.
CO3.	Isolate, characterize and estimate DNA and RNA and plasmids.
CO4.	Identify and separate of serum proteins and DNA by gel electrophoresis.
CO5.	Determine drug delivery action and drug estimation, LD50, LC50, EC50.
CO6.	Determine blood sugar, urea, cholesterol, creatine, creatinine, uric acid, albumin, SGPT, SGOT, triglycerides, LDL, VLDL, HDL acid and alkaline phosphatase and haemoglobin.

Course Description:

Laboratory exercise and field trips designed to develop student competency in biochemical description, analysis, and assessment. This laboratory course is also designed for students who plan to work directly in the field of biochemistry, toxicology, or to be involved in projects requiring practical application of applied biochemical procedures. By conducting weekly laboratory and field exercises and writing reports on their work, students will deepen their understanding of, and learn to apply, the fundamental biochemical processes. This laboratory course will provide foundational learning in biochemistry and toxicology and prepare students for further research. This laboratory course is also designed toprovide students with hands on experience in analytical procedures for assessment, testing, and interpretation.

List of Experiments:

1. Determination of total amino acid concentration by ninhydrin method.
2. Estimation of protein concentration by i) Biuret method ii) Lowry method iii) Spectrophotometric method iv) Dye binding method.
3. Estimation of reducing sugar concentration by DNSA method
4. Estimation total sugar concentration by i) Phenol-H_2SO_4 method ii) Anthrone method
5. Estimation of glucose concentration by Glucose oxidase method
6. Determination of fructose concentration by resorcinol method.
7. Estimation of DNA by diphenyl amine method.
8. Estimation of DNA by Spectrophotometric method.
9. Estimation of RNA by orcinol method.
10. Estimation of Cholesterol
11. Estimation of Inorganic phosphate by Fiske & Subbarow Method
12. Estimation of Vit. C concentration by DCPIP method
13. Isolation and Characterization of casein from milk.
14. Isolation and characterization of starch from potato.
15. Isolation of cholesterol and lecithin from egg yolk.
16. Separation and identification of serum proteins by polyacrylamide/agarose gel electrophoresis. (BSA/Hb).
17. Separation of DNA by agarose gel electrophoresis.
18. Enzyme linked immuno-sorbent assay - peroxidase, Phosphatase
19. Determination of time course of drug action, intake and elimination of drugs
20. Determination of LD_{50}, LC_{50}, EC_{50}
21. Determination of molecular weight of proteins by gel electrophoresis
22. Isolation and characterization of DNA and RNA and plasmids
23. Plasmid vectors – extraction and purification, restriction sites in plasmid vectors, Transformation of E.coli.
24. Determination of blood sugar, urea, cholesterol, creatine, creatinine, uric acid, albumin, SGPT, SGOT, triglycerides, LDL, VLDL, HDL acid and alkaline phosphatase and haemoglobin.

Text Books

1. Plummer, D., An Introduction to Practical Biochemistry, McGraw Hill Education.
2. Sadasivam, S., Biochemical Methods, New Age International Pvt Ltd Publishers.
3. Robinson, S., A Practical Guide to Toxicology and Human Health Risk Assessment, Wiley.
4. Woolley D., and Woolley, A., Practical Toxicology: Evaluation, Prediction, and Risk, CRC Press.

Reference books

1. Vasudevan, D.M., and Das, S.K., Practical Textbook Of Biochemistry For Medical Students, Jaypee Brothers Medical Publishers.
2. Mohanty, S., Practical Clinical Biochemistry, Jaypee Brothers Medical Publishers.
3. Gupta, R.C. and Bhargava, S., Practical Biochemistry, CBS.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Environmental Health, Biochemistry and Toxicology (Lab) Course Code : SEN52202		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO 1	Determine amino acids and estimations of proteins.	**PO1, PO2, PO4, PO6, PSO7, PO8, PSO1, PSO2, PSO3, PSO4**
CO 2	Estimate glucose concentration by Glucose oxidase method and fructose concentration by resorcinol method.	**PO1, PO2, PO4, PO6, PSO7, PO8, PSO1, PSO2, PSO3, PSO4**
CO 3	Isolate, characterize and estimate DNA and RNA and plasmids.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PSO1, PSO2, PSO3, PSO4**
CO 4	Identify and separate of serum proteins and DNA by gel electrophoresis.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO 5	Determine drug delivery action and drug estimation, LD50, LC50, EC50.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**
CO6	Determine blood sugar, urea, cholesterol, creatine, creatinine, uric acid, albumin, SGPT, SGOT, triglycerides, LDL, VLDL, HDL acid and alkaline phosphatase and haemoglobin.	**PO1, PO2, PO3, PO4, PO6, PSO7, PO8, PO9, PSO1, PSO2, PSO3, PSO4**

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	**Mid Term**	**Attendance**	**Class Assessment**	**End Term**
Weightage (%)	**20**	**10**	**30**	**40**

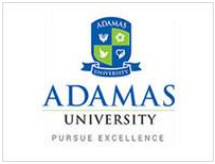
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
		Critical problem solving: Understanding quantitative reasoning and/or mathematical skills/statistical models/ geospatial technologies to study environmental problems.	Knowledge hunting: Students will be able to locate, evaluate and synthesize information from the scientific literature.	Project management: Competently implement a project, which may include literature review, experimental design, data collection, data analysis, and reporting	Interdisciplinary frame of mind: Students will gain knowledge within an interdisciplinary context in solving environmental issues such as environmental health, food and agriculture, energy, waste and pollution, climate change, population, resource management, and loss of	Ethical approach: Students will understand key concepts in the life and physical sciences and will apply them to environmental issues.	Advanced tools: Students will apply the tools commonly used in field research, particularly in the study of plants, animals, and soils and will find their way on the landscape using map, compass and GPS technology, and use spatial analysis softwares.	Environmental monitoring: To provide practical training on modern instrumentation and analytical techniques	Research aptitude: Students will be enabled to carry out an applied research project in the natural sciences.	Professional growth: Plethora of domains will be ready for the students who will successfully complete the course, to excel in.	Meaningful and socially useful employment	Encourage innovation	Professional training	Scientific communication skills	Leadership qualities
SEN52202	**Environmental Health, Biochemistry and Toxicology (Lab)**	3	2	2	1	2	3	3	2	2	3	2	1	3	1

1 = weakly mapped

2 = moderately mapped

3 = strongly mapped

Model Question Paper

Name: **Enrolment No:**	

Course: SEN52202 – Environmental Health, Biochemistry and Toxicology (Lab)

Program: M.Sc. (Environmental Science) **Time: 03 Hrs.**
Semester: Odd 2020-21 **Max. Marks: 40**
Total no. of questions:

Instructions:
Attempt all questions**.**

Section A (Attempt **all the questions)**

1.	Estimate protein concentration in the given sample.	An	CO2
2.	Estimate alkaline phosphatase in the given sample.	An	CO3

SEN52702	Seminar on contemporary research	L	T	P	C
Version 1.0		x	x	x	2
Pre-requisites/Exposure					
Co-requisites	-				

Course Objectives

1. Inculcate in the students to deal with nerves and think more positively about public speaking
2. Train the students to consider ways of grabbing the listener's attention, holding their interest, and concluding strongly
3. Teach the students how to use body language and tone of voice to enhance their presentations
4. Train the students to u slides and visual aids effectively
5. Demonstrate how to deliver an enthusiastic and well-practised presentation.

Course Outcomes

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

CO 1	Demonstrate competence in identifying relevant information, defining and explaining topics under discussion.
CO 2	Analyse when to speak and how much to say, speak clearly and audibly in a manner appropriate to the subject, ask appropriate questions, use evidence to support claims, respond to a range of questions, take part in meaningful discussion to reach a shared understanding, speak with or without notes, show depth of understanding, demonstrate breadth of reading, use primary and secondary sources, show independence and flexibility of thought, help discussions to move forward, show intellectual leadership and effective time management.
CO 3	Develop persuasive speech, present information in a compelling, well-structured, and logical sequence, respond respectfully to opposing ideas, show depth of knowledge of complex subjects, and develop their ability to synthesize, evaluate and reflect on information.
CO 4	Comprehend across diverse disciplines to apply theories, methods and knowledge bases from multiple fields to a single question or problem.

Course Description: The students will demonstrate depth of understanding, use primary and secondary sources; they will demonstrate complexity, insight, cogency, independent thought, relevance, and persuasiveness. They will be able to evaluate information and use and apply relevant theories. In terms of organization, students will be able to show competence in working with a methodology, structuring their oral work, and synthesizing information. They will demonstrate clarity, the strength of their thesis statement, and develop their topic with appropriate signposting. In terms of delivery, students will use appropriate registers and vocabulary, and will demonstrate command of voice modulation, voice projection, and pacing. They will be able to make use of visual, audio and audio-visual material to support their presentation, and will be able to speak cogently with or without notes. Students will present either in groups or as individuals. questionnaires, data tabulation and analysis, laboratory

testing, identifying and relating the factors for physical and social conditions. Submission of the prepared report and its presentation should be done by the students at the end of the course.

Modes of Evaluation: Quiz/Assignment/Presentation/Extempore/Written Examination
Examination Scheme:

Components	**Internal**	**Presentation Oral**	**Presentation Notebook**	**Understanding of the problem**	**Methodology for Field Investigation**	**Content**	**Analysis**	**Conclusion**
Weightage (%)	**20**	**15**	**15**	**10**	**10**	**10**	**10**	**10**

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO1	Demonstrate competence in identifying relevant information, defining and explaining topics under discussion.	**PO4, PO6, PO9, PSO1**
CO2	Analyse when to speak and how much to say, speak clearly and audibly in a manner appropriate to the subject, ask appropriate questions, use evidence to support claims, respond to a range of questions, take part in meaningful discussion to reach a shared understanding, speak with or without notes, show depth of understanding, demonstrate breadth of reading, use primary and secondary sources, show independence and flexibility of thought, help discussions to move forward, show intellectual leadership and effective time management.	**PO4, PO5, PO6, PO7, PO9, PSO3**
CO3	Develop persuasive speech, present information in a compelling, well-structured, and logical sequence, respond respectfully to opposing ideas, show depth of knowledge of complex subjects, and develop their ability to synthesize, evaluate and reflect on information.	**PO3, PO4, PO5, PO6, PO7, PO8, PO9, PSO3, PSO4**
CO4	Comprehend across diverse disciplines to apply theories, methods and knowledge bases from multiple fields to a single question or problem.	**PO4, PO6, PO9, PSO1**

		Physical Geography Knowledge	Social-Cultural Geography Knowledge	Contextualized Understanding	Data Analysis	Modern Tool Usage	Research Skills	Societal Implication	Environment and Sustainability	Communication and Leadership	Ethics	Understanding Natural & Social processes	Resource Management	Data analysis and Research Skills	Utilize Modem skills in Decision Making
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
SEN52702	**Seminar on contemporary research**	-	-	2	3	3	3	3	2	3	-	2	-	3	3

1=weakly mapped; 2= moderately mapped; 3=strongly mapped

SEN52704	Dissertation	L	T	P	C
Version 1.0		x	x	x	10
Pre-requisites/Exposure					
Co-requisites	-				

Course Objectives

The Dissertation modules enable participants to develop knowledge and understanding of a specialist area within the broad fields of research and development, career orientation, and professional learning. The modules are implemented principally via individual supervision and a dissertation guide. The dissertation should demonstrate competence in the following areas, as applicable to their chosen dissertation topic, critically appraising and interpreting published literature and collecting and using data and information to answer a research question.

Course Outcomes

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

CO 1	Plan, and engage in, an independent and sustained critical investigation and evaluation of a chosen research topic relevant to environment.
CO 2	Identify relevant theory and concepts, relate these to appropriate methodologies and evidence, apply appropriate techniques and draw appropriate conclusions
CO 3	Engage in systematic discovery and critical review of appropriate and relevant information sources
CO 4	Apply qualitative and/or quantitative evaluation processes to original data
CO 5	Apply ethical standards of conduct in the collection and evaluation of data and other resources
CO 6	Interpret and communicate research concepts and contexts clearly and effectively both in writing and orally

Course Description: This module will provide the student with guidance and support throughout the writing of dissertation. From discussing the initial ideas of the dissertation through the process of actually writing the document, this module will provide him/her with the information and support required from both the in-house teaching staff and the allocated dissertation supervisor. The aim of this module is to enable students to develop an understanding and obtain practical experience of the research process and research skills required to undertake a supervised research project. Students will be required to identify relevant information on a topic and critically review the research of others. A range of approaches should be used to assess the impact this information will have on either the planning of services or improving health. It typically involves a literature review and an appropriate form of critical analysis of sources of primary and /or secondary data; it may involve field and/or laboratory work. The dissertation must show evidence of wide reading and understanding, of critical analysis and/or appropriate use of advanced research techniques. All students must attend relevant seminars, present at least one seminar, and comply with any other prescribed conditions.

Modes of Evaluation: Quiz/Assignment/Presentation/Extempore/Written Examination
Examination Scheme:

Components	Internal	Presentation Oral	Presentation Notebook	Understanding of the problem	Methodology for Field Investigation	Content	Analysis	Conclusion
Weightage (%)	**20**	**15**	**15**	**10**	**10**	**10**	**10**	**10**

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO1	Plan, and engage in, an independent and sustained critical investigation and evaluation of a chosen research topic relevant to environment.	**PO4, PO6, PO9, PSO1**
CO2	Identify relevant theory and concepts, relate these to appropriate methodologies and evidence, apply appropriate techniques and draw appropriate conclusions	**PO4, PO5, PO6, PO7, PO9, PSO3**
CO3	Engage in systematic discovery and critical review of appropriate and relevant information sources	**PO3, PO4, PO5, PO6, PO7, PO8, PO9, PSO3, PSO4**
CO4	Apply qualitative and/or quantitative evaluation processes to original data	**PO4, PO6, PO9, PSO1**
CO 5	Apply ethical standards of conduct in the collection and evaluation of data and other resources	**PO4, PO6, PO9, PSO1**
CO 6	Interpret and communicate research concepts and contexts clearly and effectively both in writing and orally	**PO4, PO6, PO9, PSO1**

		Physical Geography Knowledge	Social-Cultural Geography Knowledge	Contextualized Understanding	Data Analysis	Modern Tool Usage	Research Skills	Societal Implication	Environment and Sustainability	Communication and Leadership	Ethics	Understanding Natural & Social processes	Resource Management	Data analysis and Research Skills	Utilize Modern skills in Decision Making
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
SEN52704	**Dissertation**	-	-	2	3	3	3	3	2	3	-	2	-	3	3

1=weakly mapped; 2= moderately mapped; 3=strongly mapped

SEN52706	Grand Viva	L	T	P	C
Version 1.0		x	x	x	2
Pre-requisites/Exposure					
Co-requisites	-				

Course Objectives

The objective of comprehensive viva-voce is to assess the overall knowledge of the student in the relevant field of Environmental Science acquired over 2 years of study in the post graduate program.

Course Outcomes

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

CO 1	Demonstrate and ensure that comprehensive knowledge on all subjects related to M.Sc. covered in four years, has been imparted
CO 2	Understand on inherent philosophy of the basic concepts of the core subjects.
CO 3	Engage in systematic discovery and critical review of appropriate and relevant information sources
CO 4	Get accustomed with virtual environment of technical interview.
CO 5	Illustrate confidence and versatility in answering the varieties of questions posed by a group of faculty members in a moderately short duration.

Course Description: Every student will be required to undergo comprehensive viva voce at the end of 4th semester of the M.Sc. Programme. The duration of the viva will range from 15-30 min. The examination committee will be constituted by the HoD and consist of at least three faculties.

Modes of Evaluation: Quiz/Assignment/Presentation/Extempore/Written Examination
Examination Scheme:

Components	Internal	Presentation Oral	Presentation Notebook	Understanding of the problem	Methodology for Field Investigation	Content	Analysis	Conclusion
Weightage (%)	**20**	**15**	**15**	**10**	**10**	**10**	**10**	**10**

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO1	Demonstrate and ensure that comprehensive knowledge on all subjects related to M.Sc. covered in four years, has been imparted	**PO4, PO6, PO9, PSO1**
CO2	Understand on inherent philosophy of the basic concepts of the core subjects.	**PO4, PO5, PO6, PO7, PO9, PSO3**
CO3	Engage in systematic discovery and critical review of appropriate and relevant information sources	**PO3, PO4, PO5, PO6, PO7, PO8, PO9, PSO3, PSO4**
CO4	Get accustomed with virtual environment of technical interview.	**PO4, PO6, PO9, PSO1**
CO 5	Illustrate confidence and versatility in answering the varieties of questions posed by a group of faculty members in a moderately short duration.	**PO4, PO6, PO9, PSO1**

		Physical Geography Knowledge	Social-Cultural Geography Knowledge	Contextualized Understanding	Data Analysis	Modern Tool Usage	Research Skills	Societal Implication	Environment and Sustainability	Communication and Leadership	Ethics	Understanding Natural & Social processes	Resource Management	Data analysis and Research Skills	Utilize Modern skills in Decision Making
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
SEN52706	**Grand Viva**	-	-	2	3	3	3	3	2	3	-	2	-	3	3

1=weakly mapped; 2= moderately mapped; 3=strongly mapped

ADAMAS UNIVERSITY, KOLKATA
SCHOOL OF BASIC AND APPLIED SCIENCES
DEPARTMENT OF CHEMISTRY
CO-PO and PSO Mapping
PROGRAMME: M.Sc. IN ENVIRONMENTAL SCIENCE

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
SEN51101	Energy and environment	3	3	3	3	2	1	3	3	3	2	1	2	3	2
SEN51103	Environmental Chemistry	3	3	3	3	2	1	3	3	3	2	1	2	3	-
SEN51105	Atmospheric science	2	3	3	3	3	2	3	3	3	2	2	2	3	1
SEN51107	Ecology and biodiversity	2	3	2	3	3	1	3	3	3	2	2	2	3	1
SEN51109	Natural Resources and Environment	2	2	2	3	3	2	2	3	3	3	2	2	1	1
SEN51201	Environmental chemistry Lab	2	2	2	2	-	2	3	3	3	3	2	2	3	-
SEN51203	Ecology Lab	2	2	2	2	-	2	3	3	3	3	2	2	3	-
SEN51701	Field visit	2	3	3	3	3	2	3	3	3	2	2	2	3	1
SMA51171	Mathematics Foundation	3	-	-	3	-	-	-	-	-	-	3	-	-	-
SEN51102	Air Pollution and control technologies	2	3	3	3	3	2	3	3	3	2	2	2	3	1
SEN51104	Water Pollution and Control Technologies	3	3	3	3	3	3	3	3	3	2	2	2	3	2
SEN51106	Environmental Geosciences	2	3	3	3	3	3	3	3	3	2	2	3	3	2
SEN51108	Environmental Instrumentation	3	3	3	3	2	3	3	3	3	2	2	3	3	2
SEN51202	Environmental Monitoring Laboratory	2	2	2	2	-	2	3	3	3	3	2	2	3	-
SEN51204	Environmental	2	2	2	2	-	2	3	3	3	3	2	2	3	-

	Instrumentation Lab														
SEN51206	**Environmental Geoscience Lab**	2	2	2	2	-	2	3	3	3	3	2	2	3	-
SEN51702	**Industry Internship**	2	3	3	3	3	2	3	3	3	2	2	2	3	1
SEN52101	**Statistical Applications in Environmental Systems**	2	3	3	3	2	3	3	3	2	3	3	2	2	2
SEN52103	**Solid and Hazardous Waste Management**	2	3	3	3	3	2	3	3	3	2	2	2	3	1
SEN52105	**Environmental Microbiology and Biotechnology**	2	3	2	2	2	3	3	3	2	3	3	2	2	1
SEN52107	**Elective I Sensing GIS for Environmental Planning and Management**	2	3	3	3	3	2	3	3	3	2	2	2	3	1
SEN52109	**Soil Science**	2	3	3	3	3	2	3	3	3	2	2	2	3	1
SEN52201	**Environmental computation Lab**	3	2	2	1	2	3	3	2	3	3	-	1	3	1
SEN52203	**Elective I Remote Sensing and GIS for Environmental Planning and Management Lab**	3	2	2	1	2	3	3	2	3	3	-	1	3	1
SEN52205	**Elective I Soil Science Laboratory**	3	2	2	1	2	3	3	2	3	3	-	1	3	1
SEN52207	**Environmental Microbiology and Biotechnology**	3	2	2	1	2	3	3	2	3	3	3	1	3	1
SEN52701	**Excursion**	-	-	2	3	3	3	3	2	3	-	2	-	3	3
SEN52102	**Environmental Impact Assessment and Regulatory Framework**	2	3	3	3	3	2	3	3	3	2	2	2	3	1

SEN52104	**Elective Paper II Industrial pollution prevention and clean technologies**	2	3	3	3	3	2	3	3	3	2	2	2	3	1
SEN52106	**Design for water and wastewater systems**	3	3	3	3	3	3	3	3	3	2	2	2	3	2
SEN52108	**Elective III Environmental Economics, Ethics and Policies**	2	3	3	3	3	2	3	3	3	2	2	2	3	1
SEN52110	**Elective III Occupational health safety and Environmental Management**	2	3	3	3	3	2	3	3	3	2	2	2	3	1
SEN52112	**Environmental Health, Biochemistry and Toxicology**	2	3	2	3	2	2	3	3	3	1	2	2	3	1
SEN52202	**Environmental Health, Biochemistry and Toxicology (Lab)**	3	2	2	1	2	3	3	2	2	3	2	1	3	1
SEN52702	**Seminar on contemporary research**	-	-	2	3	3	3	3	2	3	-	2	-	3	3
SEN52704	**Dissertation**	-	-	2	3	3	3	3	2	3	-	2	-	3	3
SEN52706	**Grand Viva**	-	-	2	3	3	3	3	2	3	-	2	-	3	3
Average of CO-PO Mapping		2.33	2.66	2.50	2.57	2.65	2.33	2.97	2.75	2.92	2.38	2.06	1.91	2.89	1.47