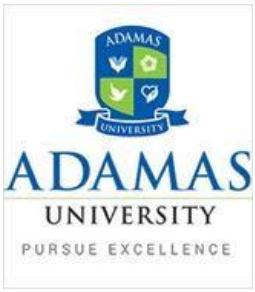

Adamas University
School of Basic and Applied Sciences
Department of Chemistry

Programme Structure and Syllabus of B.Sc. (Hons.) Environmental Science

Programme Code: CHM3304
Duration: 3 Years Full Time
Academic Year 2022-2023

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 of the University

- Improve employability through futuristic curriculum and progressive pedagogy with cutting-edge technology
- Foster outcomes-based education system for continuous improvement in education, research and all allied activities
- Instil the notion of lifelong learning through culture of research and innovation
- Collaborate with industries, research centres and professional bodies to stay relevant and up to date
- Inculcate ethical principles and develop understanding of environmental and social realities

Core Values

- Respect
- Positivity
- Commitment
- Accountability
- Innovation

Vision of the School

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

Mission of the School

- Develop solutions for the challenges in sciences through value-based science education.
- Conduct research leading to innovation in sciences.
- Nurture students into scientifically competent professionals in the usage of modern tools.
- Foster in students, a spirit of inquiry and collaboration to make them ready for careers in teaching, research and corporate world.

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 of the Department

- 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.
- 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.
- 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.
- 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.

Programme Educational Objectives (PEO) of BSc Environmental Science

PEO1: Graduates will be able to apply scientific principles to identify and evaluate environmental problems, and develop evidence-based solutions to address them.

PEO2: Graduates will be able to critically Analyse and interpret data related to environmental processes and systems, and communicate findings effectively to a variety of audiences.

PEO3: Graduates will be able to understand and apply principles of sustainability and environmental ethics, and evaluate the potential social, economic, and environmental impacts of policies and practices related to natural resource management and environmental protection.

PEO4: Graduates will be able to apply knowledge of environmental science to contribute to the development and implementation of strategies for environmental management and conservation at local, regional, and global scales.

PEO5: Graduates will be able to work collaboratively and effectively in interdisciplinary teams to address complex environmental challenges, and demonstrate the ability to learn independently and engage in lifelong learning to keep pace with advancements in the field.

Programme Outcomes (POs) of BSc Environmental Science

PO1	**Interdisciplinary Scientific Knowledge**	Graduates will have a broad understanding of the natural and social sciences as they relate to the environment, including biology, chemistry, physics, geology, economics, and sociology.
PO2	**Core Competence**	Graduates will have a strong foundation in the principles and practices of environmental science, including topics such as ecology, environmental chemistry, environmental policy, and sustainability.
PO3	**Research and Analytical Skills**	Graduates will be able to apply scientific methods to design and conduct experiments, Analyse data, and draw conclusions related to environmental problems.
PO4	**Communication Proficiency**	Graduates will be able to communicate effectively about environmental issues and research findings to a variety of audiences, including technical and non-technical audiences.
PO5	**Ethical and Social Awareness**	Graduates will understand the ethical and social dimensions of environmental problems, and be able to consider the perspectives of diverse stakeholders in developing solutions.
PO6	**Field and Laboratory Expertise**	Graduates will have experience with field work and laboratory methods commonly used in environmental science, and be able to use equipment and instrumentation necessary for environmental research.
PO7	**Collaboration and Teamwork**	Graduates will understand the importance of collaboration and teamwork in addressing complex environmental challenges, and be able to work effectively in interdisciplinary teams.
PSO1		Graduates will be prepared for a range of careers related to environmental science, including positions in environmental consulting, non-profit organizations, government agencies, and private industry, or for pursuing graduate studies in a related field.
PSO2		Graduates will possess the skills to develop and implement environmental management plans, sustainability strategies, and policy recommendations aimed at conserving resources, reducing environmental footprints, and promoting sustainable development in various sectors.
PSO3		Graduates will be proficient in environmental data analysis, including the use of statistical software, Geographic Information Systems (GIS), and remote sensing techniques to assess environmental patterns, monitor changes, and support evidence-based decision-making in environmental management.

Program Outcome Vs Courses Mapping Table of Semester: I

Course Code	Course Name	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
EVS11201	Earth and Earth Surface Processes	CO1	2	2	3	3	2	1	3	1	3	3
		CO2	3	1	1	2	2	2	2	2	2	1
		CO3	3	1	2	2	1	2	2	3	2	2
		CO4	2	1	1	3	2	3	2	1	1	1
		CO5	3	3	2	3	3	1	1	3	2	2
		CO	2.6	1.6	1.8	2.6	2	1.8	2	2	2	1.8
EVS11202	Physics and Chemistry of the Environment	CO1	2	2	1	3	2	1	2	1	1	2
		CO2	3	1	3	-	1	3	2	-	2	-
		CO3	2	2	2	2	2	1	2	2	2	2
		CO4	2	1	1	3	2	2	3	1	3	1
		CO5	3	3	2	3	3	1	2	2	-	2
		CO	2.4	1.8	1.8	2.2	2	1.6	2.2	1.2	1.6	1.4
EVS11203	Energy and Environment	CO1	2	2	3	3	2	1	2	1	3	3
		CO2	2	1	1	2	2	2	1	2	2	1
		CO3	3	2	2	1	2	2	2	2	2	2
		CO4	3	3	2	3	2	2	2	1	3	3
		CO5	3	2	1	2	3	3	1	3	1	2
		CO	2.6	2	1.8	2.2	2.2	2	1.6	1.8	2.2	2.2
EVS12204	Earth and Earth Surface Processes Lab	CO1	2	2	3	3	2	1	2	1	3	3
		CO2	2	3	1	2	1	2	2	2	2	2
		CO3	3	2	2	2	2	2	3	2	2	2
		CO4	1	1	2	3	2	2	2	1	1	1
		CO5	3	2	2	1	3	1	1	3	1	2
		CO	2.2	2	2	2.2	2	1.6	2	1.8	1.8	2
EVS12205	Physics and Chemistry of Environment Lab	CO1	2	2	1	3	2	1	2	1	1	2
		CO2	3	1	3	-	2	3	2	-	2	-
		CO3	2	2	2	2	3	1	2	2	1	3
		CO4	2	3	1	1	2	2	3	1	2	1
		CO5	3	2	2	3	3	1	2	2	-	2
		CO	2.4	2	1.8	2.25	2.4	1.6	2.2	1.5	1.5	2

EVS12206	Energy and Environment Lab	**COs**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PSO1**	**PSO2**	**PSO3**
		CO1	2	2	1	3	2	1	2	1	1	2
		CO2	2	3	3	-	2	3	2	-	2	-
		CO3	3	2	1	2	3	1	2	2	2	2
		CO4	2	1	2	3	2	2	2	3	3	1
		CO5	3	2	2	3	3	1	2	2	-	2
		CO	2.4	2	1.8	2.75	2.4	1.6	2	2	2	1.75

Correlation level 1, 2 and 3 as defined below:

"1" – Slight (Low)
"2" - Moderate (Medium)
"3" – Substantial (High)
"-" – No correlation

School of Basic and Applied Sciences
BSc (Hons) Environmental Science
Batch: 2022-23
Semester: I

S. No.	Type of Course	Course Code	Course Title	Teaching Load				CREDITS
				L	**T**	**P**	**TOTAL**	
1.	Core Theory	EVS11201	Earth and Earth Surface Processes	4	0	0	4	4
2.	Core Theory	EVS11202	Physics and Chemistry of the Environment	4	0	0	4	4
3.	Core Theory	EVS11203	Energy and Environment	4	0	0	4	4
4.	GE Theory	CHM11151	Generic Elective Chemistry I	3	1	0	4	4
5.	AECC Theory	ENG11057	AECC-1: English Communication (Modern Indian Language)	2	0	0	2	2
6.	Value Added Course	DSG11011	Design Thinking	2	0	0	2	2
7.	Core Practical	EVS12204	Earth and Earth Surface Processes Lab	0	0	3	3	2
8.	Core Practical	EVS12205	Physics and Chemistry of Environment Lab	0	0	3	3	2
9.	Core Practical	EVS12206	Energy and Environment Lab	0	0	3	3	2
10.	GE Practical	CHM12152	Generic Elective Chemistry-I Lab	0	0	3	3	2
			Total	**19**	**1**	**12**		**28**

SYLLABUS

Earth and Earth Surface Processes

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	I
Course Title	Earth and Earth Surface Processes
Course Code	EVS11201
Credit	4
Contact Hours (L-T-P)	4-0-0
Course Type	Theory
Course Objective	The objectives of this course are • Understand the fundamental concepts of plate tectonics, including the types of plate boundaries, the processes that occur at these boundaries, and the resulting geologic hazards such as earthquakes and volcanic eruptions. • Identify and describe the major rock types and minerals, and explain how they are formed through geologic processes such as igneous activity, sedimentation, and metamorphism. • Recognize and interpret geologic maps, cross-sections, and stratigraphic columns, and understand how they provide information about the history and structure of the Earth's crust. • Analyse and interpret topographic maps, satellite imagery, and other data sources to identify and describe different types of landforms and landscapes and explain how they are shaped by tectonic and erosion processes. • Evaluate the impacts of natural hazards and human activities on Earth surface processes and develop strategies for mitigating these impacts through sustainable land use practices and other means.
Course Outcome (CO)	After completion of this course, students will be able to:

	CO1: Describe and explain the major processes and features associated with plate tectonics, including the types of plate boundaries, earthquakes, volcanoes, and mountain building. **CO2:** Identify and describe different types of rocks, including igneous, sedimentary, and metamorphic rocks, and explain how they are formed and how their characteristics reflect their geologic history. **CO3:** Analyse and interpret topographic maps, satellite imagery, and other data sources to identify and describe different types of landforms and landscapes, and explain how they are shaped by tectonic and erosion processes. **CO4:** Identify and describe different types of erosion and sediment transport processes, including weathering, mass wasting, fluvial erosion, and coastal erosion, and explain how they affect landscapes and shape landforms. **CO5:** Recognize and evaluate the potential impacts of natural hazards and human activities on Earth surface processes and suggest potential strategies for mitigating these impacts.

Course Outline

Unit	Description
I	**History of Earth:** Introduction of Solar system, formation of the Earth: formation and composition of core, mantle, crust, lithosphere, atmosphere and hydrosphere; chemical composition of Earth; geological time scale and major changes on the Earth's surface.
II	**Earth system processes:** Continental drift, Pangaea and present-day continents, evidence of continental drift; Ocean floor and seafloor spreading; Plate tectonics, major plates and hot spots, plate boundaries, mantle convection and movement of lithosphere plates; earthquakes; volcanic activities; orogeny; isostasy; gravitational and magnetic fields of the earth; origin of the main geomagnetic field; continental collision and mountain formation with specific example of the Himalaya.
III	**Minerals and rocks:** Minerals and important rock forming minerals; rock cycle: lithification and metamorphism; Three rock laws; rock structure, igneous, sedimentary, and metamorphic rocks; weathering: physical, biogeochemical processes; erosion: physical processes of erosion, factors affecting erosion; agents of erosion: rivers and streams, glacial and aeolian transportation and deposition of sediments by running water, wind and glaciers.
IV	**Earth surface processes**: Atmosphere: evolution of earth's atmosphere, composition of atmosphere, physical and optical properties, circulation; interfaces: atmosphere–ocean interface, atmosphere–land interface, ocean–land interface; land surface processes: fluvial and glacial processes, rivers and geomorphology; types of glaciers, glacier dynamics, erosional and depositional processes and glaciated landscapes; coastal processes.

V	**Importance of mountains in Environmental processes:** Formation of Peninsular Indian Mountain systems - Western and Eastern Ghats, Vindhyas, Aravallis, etc. Formation of the Himalaya; development of glaciers, perennial river systems and evolution of monsoon in Indian subcontinent; formation of Indo-Gangetic Plains, evolution of Indus Valley civilization; progression of agriculture in the Indian subcontinent; withdrawing monsoon and lessons to draw.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text and Reference Books:

1. Bridge, J., & Demicco, R. 2008. Earth Surface Processes, Landforms and Sediment deposits. Cambridge University Press.
2. Duff, P. M. D., & Duff, D. (Eds.). 1993. Holme's Principles of Physical Geology. Taylor & Francis.
3. Gupta, A. K., Anderson, D. M., & Overpeck, J. T. 2003. Abrupt changes in the Asian southwest monsoon during the Holocene and their links to the North Atlantic Ocean. Nature 421: 354-357.
4. Gupta, A. K., Anderson, D. M., Pandey, D. N., & Singhvi, A. K. 2006. Adaptation and human migration, and evidence of agriculture coincident with changes in the Indian summer monsoon during the Holocene. Current Science 90: 1082-1090.
5. Keller, E.A. 2011. Introduction to Environmental Geology (5th edition). Pearson Prentice Hall.
6. Krishnan, M. S. 1982. Geology of India and Burma. CBS Publishers & Distributors.
7. Leeder, M., Arlucea, M.P. 2005. Physical Processes in Earth and Environmental Sciences. Blackwell Publishing.
8. Pelletier, J. D. 2008. Quantitative Modeling of Earth Surface Processes (Vol. 304). Cambridge: Cambridge University Press. Chicago.

Physics and Chemistry of the Environment

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	I
Course Title	Physics and Chemistry of the Environment
Course Code	EVS11202
Credit	4
Contact Hours (L-T-P)	4-0-0
Course Type	Theory
Course Objective	The objectives of this course are • To provide an in-depth understanding of the physical and chemical processes that occur in the environment, including the atmosphere, hydrosphere, and lithosphere. • To develop an understanding of the interactions between different environmental systems, such as the atmosphere-ocean system or the soil-water system. • To examine the sources and fate of pollutants in the environment, including the mechanisms by which pollutants are transported, transformed, and degraded. • To explore the impact of human activities on the environment, including the role of energy consumption, land use change, and waste generation in driving environmental change. • To introduce students to the principles of environmental monitoring and measurement, including sampling techniques, analytical methods, and data interpretation. • To foster an appreciation for the complexity and interconnectedness of the natural world, and to develop critical thinking skills for evaluating environmental issues and policies.

Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Develop a deep understanding of the fundamental physical and chemical principles that govern environmental processes, including the atmosphere, hydrosphere, and lithosphere. **CO2:** Analyse the interactions between different environmental systems and evaluate the impact of natural and anthropogenic factors on these systems. **CO3:** Evaluate the sources and fate of pollutants in the environment and assess the potential risks to human health and ecosystems. **CO4:** Apply principles of environmental monitoring and measurement to design and conduct experiments, analyse data, and interpret results. **CO5:** Communicate scientific findings and policy recommendations related to environmental issues effectively, both orally and in writing, to a variety of audiences.

Course Outline

Unit	Description
I	**Fundamentals of Environmental Physics:** Basic concepts of pressure, force, work and energy; types of forces and their relation (pressure gradient, viscous, Coriolis, gravitational, centripetal, and centrifugal force); concept of heat transfer, conduction, convection; concept of temperature, lapse rate (dry and moist adiabatic); laws of thermodynamics; concept of heat and work, Carnot engine, transmission of electrical power, efficiency of turbines, wind-mills and hydroelectric power plants. Basic concepts of light and matter; spectroscopic concepts: Introduction to the concept of absorption and transmission of light, Beer–Lambert law, photovoltaic and solar cells; scattering of light, Rayleigh and Mie's scattering.
II	**Fundamentals of environmental chemistry:** Atomic structure, electronic configuration, periodic properties of elements (ionization potential, electron affinity and electronegativity), types of chemical bonds (ionic, covalent, coordinate and hydrogen bonds); mole concept, molarity and normality, quantitative volumetric analysis. Thermodynamics and chemical equilibrium; types of chemical reactions; acids, bases and salts, solubility products; solutes and solvents; redox reactions, concepts of pH and pE, electrochemistry, Nernst equation, electrochemical cells. Basic concepts of organic chemistry, hydrocarbons, aliphatic and aromatic compounds, organic functional groups, polarity of the functional groups, basic concepts of organic synthesis.
III	**Atmospheric chemistry:** Composition of atmosphere; photochemical reactions in atmosphere; smog formation, types of smog (sulphur smog and photochemical smog),

	aerosols; chemistry of acid rain, case studies; reactions of NO 2 and SO 2 ; free radicals and ozone layer depletion, role of CFCs in ozone depletion.
IV	**Water chemistry:** Chemical and physical properties of water; alkalinity and acidity of water, hardness of water, calculation of total hardness; solubility of metals, complex formation and chelation; colloidal particles; heavy metals and metalloids in water.
V	**Soil chemistry:** Soil composition; relation between organic carbon and organic matter, inorganic and organic components in soil; soil humus; cation and anion exchange reactions in soil; nitrogen, phosphorus and potassium in soil; phenolic compounds in soil.
VI	**Movement of pollutants in environment:** Diffusion and dispersion, point, line and area source pollutants, pollutant dispersal; Gaussian plume model, Inversion and mixing heights, hydraulic potential, Darcy's equation, types of flow, laminar and turbulence, super-critical, critical and sub-critical.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text and Reference Books:

1. Beard, J.M. 2013. Environmental Chemistry in Society (2nd edition). CRC Press.
2. Boeker, E. &Grondelle, R. 2011. Environmental Physics: Sustainable Energy and Climate Change. Wiley.
3. Connell, D.W. 2005. Basic Concepts of Environmental Chemistry (2nd edition). CR Press.
4. Forinash, K. 2010. Foundation of Environmental Physics. Island Press.
5. Girard, J. 2013. Principles of Environmental Chemistry (3rd edition). Jones & Bartlett.
6. Harnung, S.E. & Johnson, M.S. 2012. Chemistry and the Environment. Cambridg University Press.
7. Hites, R.A. 2012. Elements of Environmental Chemistry (2nd edition). Wiley & Sons.
8. Manahan, S. E. 2000. Fundamentals of Environmental Chemistry. CRC Press.
9. Pani, B. 2007. Textbook of Environmental Chemistry. IK international Publishing House.

Energy and Environment

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	I
Course Title	Energy and Environment
Course Code	EVS11203
Credit	4
Contact Hours (L-T-P)	4-0-0
Course Type	Theory
Course Objective	The objectives of this course are • To provide a comprehensive understanding of the relationship between energy and the environment, including the environmental impacts of energy production, distribution, and consumption. • To develop an understanding of the different forms of energy, including renewable and non-renewable sources, and their potential for meeting current and future energy needs. • To explore the technological, economic, and social factors that influence energy use and the transition to a sustainable energy future. • To evaluate the environmental impacts of different energy sources, including the emissions of greenhouse gases, air pollutants, and the depletion of natural resources. • To Analyse the policies and regulations that govern energy and the environment at the local, national, and international levels, and their effectiveness in promoting sustainability. • To foster critical thinking skills for evaluating energy and environmental issues, and to develop effective communication skills for presenting scientific findings and policy recommendations.

Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Understand the relationship between energy and the environment, and evaluate the environmental impacts of energy production, distribution, and consumption. **CO2:** Analyse the potential of different energy sources, including renewable and non-renewable sources, to meet current and future energy needs, and evaluate their environmental impacts. **CO3:** Evaluate the technological, economic, and social factors that influence energy use and the transition to a sustainable energy future. **CO4:** Analyse the policies and regulations that govern energy and the environment at the local, national, and international levels, and assess their effectiveness in promoting sustainability. **CO5:** Apply critical thinking skills to evaluate energy and environmental issues, and effectively communicate scientific findings and policy recommendations to a variety of audiences.

Course Outline

Unit	Description
I	**Introduction:** Defining energy; forms and importance; energy use from a historical perspective: discovery of fire, discovery of locomotive engine and fossil fuels, electrification of cities, oil wars in the Middle East, advent of nuclear energy; sources and sinks of energy; energy over-consumption in urban setting.
II	**Energy resources:** Global energy resources; renewable and non-renewable resources, specific examples: distribution and availability; past, present, and future technologies for capturing and integrating these resources into our energy infrastructure; energy-use scenarios in rural and urban setups; energy conservation.
III	**Energy demand:** Global energy demand: historical and current perspective; energy demand and use in domestic, industrial, agriculture and transportation sector; generation and utilization in rural and urban environments; changes in demand in major world economies; energy subsidies and environmental costs.
IV	**Energy, environment, and society:** Nature, scope and analysis of local and global impacts of energy use on the environment; fossil fuel burning and related issues of air pollution, greenhouse effect, global warming and urban heat island effect; nuclear energy and related issues such as radioactive waste, spent fuel; social inequalities related to energy production, distribution, and use.
V	**Energy and the environment:** Energy production as driver of environmental change; energy production, transformation and utilization associated environmental impacts (Chernobyl and Fukushima nuclear accidents, construction of dams, environmental pollution); energy over-consumption and its impact on the environment, economy, and global change.

VI	**Politics of energy policy:** Political choices in energy policy globally and in the Indian context (historical and contemporary case studies); domestic and international energy policy; energy diplomacy and bilateral ties of India with her neighbours.
VII	**Our energy future:** Current and future energy use patterns in the world and in India; evolution of energy use over time; alternative sources as green energy (biofuels, wind energy, solar energy, geothermal energy; ocean energy; nuclear energy); need for energy efficiency; energy conservation and sustainability; action strategies for sustainable energy mix and management from a future perspective.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text and Reference Books:

1. McKibben, B. 2012. Global Warming's Terrifying New Math, Rolling Stone Magazine.
2. Craig. J.R., Vaughan, D.J., Skinner. B.J. 1996. Resources of the Earth: Origin, use, and environmental impact (2nd edition). Prentice Hall, New Jersey.
3. Elliott, D. 1997. Sustainable Technology. Energy, Society and Environment (Chapter 3). New York, Routledge Press.
4. Rowlands, I.H. 2009. Renewable Electricity: The Prospects for Innovation and Integration in Provincial Policies in Debora L. Van Nijnatten and Robert Boardman (eds), Canadian Environmental Policy and Politics: Prospects for Leadership and Innovation, Third Edition. Oxford University Press, pp. 167-82.
5. Oliver, J. 2013. Dispelling the Myths about Canada's Energy Future, Policy: Canadian Politics and Public Policy, June-July.
6. Mallon, K. 2006. Myths, Pitfalls and Oversights, Renewable Energy Policy and Politics: A Handbook for Decision-Making. EarthScan.

Design Thinking

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	I
Course Title	Design Thinking
Course Code	DGS11011
Credit	2
Contact Hours (L-T-P)	2-0-0
Course Type	Theory
Course Objective	The objectives of this course are • To provide a comprehensive understanding of the relationship between energy and the environment, including the environmental impacts of energy production, distribution, and consumption. • To develop an understanding of the different forms of energy, including renewable and non-renewable sources, and their potential for meeting current and future energy needs. • To explore the technological, economic, and social factors that influence energy use and the transition to a sustainable energy future. • To evaluate the environmental impacts of different energy sources, including the emissions of greenhouse gases, air pollutants, and the depletion of natural resources. • To Analyse the policies and regulations that govern energy and the environment at the local, national, and international levels, and their effectiveness in promoting sustainability. • To foster critical thinking skills for evaluating energy and environmental issues, and to develop effective communication skills for presenting scientific findings and policy recommendations.

Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Understand the relationship between energy and the environment, and evaluate the environmental impacts of energy production, distribution, and consumption. **CO2:** Analyse the potential of different energy sources, including renewable and non- renewable sources, to meet current and future energy needs, and evaluate their environmental impacts. **CO3:** Evaluate the technological, economic, and social factors that influence energy use and the transition to a sustainable energy future. **CO4:** Analyse the policies and regulations that govern energy and the environment at the local, national, and international levels, and assess their effectiveness in promoting sustainability. **CO5:** Apply critical thinking skills to evaluate energy and environmental issues, and effectively communicate scientific findings and policy recommendations to a variety of audiences.

Course Outline

Unit	Description
I	**Introduction:** Defining energy; forms and importance; energy use from a historical perspective: discovery of fire, discovery of locomotive engine and fossil fuels, electrification of cities, oil wars in the Middle East, advent of nuclear energy; sources and sinks of energy; energy over- consumption in urban setting.
II	**Energy resources:** Global energy resources; renewable and non-renewable resources, specific examples: distribution and availability; past, present, and future technologies for capturing and integrating these resources into our energy infrastructure; energy-use scenarios in rural and urban setups; energy conservation.
III	**Energy demand:** Global energy demand: historical and current perspective; energy demand and use in domestic, industrial, agriculture and transportation sector; generation and utilization in rural and urban environments; changes in demand in major world economies; energy subsidies and environmental costs.
IV	**Energy, environment, and society:** Nature, scope and analysis of local and global impacts of energy use on the environment; fossil fuel burning and related issues of air pollution, greenhouse effect, global warming and urban heat island effect; nuclear energy and related issues such as radioactive waste, spent fuel; social inequalities related to energy production, distribution, and use.
V	**Energy and the environment:** Energy production as driver of environmental change; energy production, transformation and utilization associated environmental impacts (Chernobyl and Fukushima nuclear accidents, construction of dams, environmental pollution); energy over-consumption and its impact on the environment, economy, and global change.

VI	**Politics of energy policy:** Political choices in energy policy globally and in the Indian context (historical and contemporary case studies); domestic and international energy policy; energy diplomacy and bilateral ties of India with her neighbours.
VII	**Our energy future:** Current and future energy use patterns in the world and in India; evolution of energy use over time; alternative sources as green energy (biofuels, wind energy, solar energy, geothermal energy; ocean energy; nuclear energy); need for energy efficiency; energy conservation and sustainability; action strategies for sustainable energy mix and management from a future perspective.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text and Reference Books:

1. McKibben, B. 2012. Global Warming's Terrifying New Math, Rolling Stone Magazine.
2. Craig. J.R., Vaughan, D.J., Skinner. B.J. 1996. Resources of the Earth: Origin, use, and environmental impact (2nd edition). Prentice Hall, New Jersey.
3. Elliott, D. 1997. Sustainable Technology. Energy, Society and Environment (Chapter 3). New York, Routledge Press.
4. Rowlands, I.H. 2009. Renewable Electricity: The Prospects for Innovation and Integration in Provincial Policies in Debora L. Van Nijnatten and Robert Boardman (eds), Canadian Environmental Policy and Politics: Prospects for Leadership and Innovation, Third Edition. Oxford University Press, pp. 167-82.
5. Oliver, J. 2013. Dispelling the Myths about Canada's Energy Future, Policy: Canadian Politics and Public Policy, June-July.
6. Mallon, K. 2006. Myths, Pitfalls and Oversights, Renewable Energy Policy and Politics: A Handbook for Decision-Making. EarthScan.

Earth and Earth Surface Processes Lab

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	I
Course Title	Earth and Earth Surface Processes Lab
Course Code	EVS12204
Credit	2
Contact Hours (L-T-P)	0-0-3
Course Type	Practical
Course Objective	The objectives of this course are • To provide students with hands-on experience in conducting scientific investigations related to the Earth and its processes. • To introduce students to various tools and techniques used in the field of Earth Sciences, such as laboratory analysis, data collection, and interpretation. • To help students develop critical thinking and problem-solving skills by analysing and interpreting data from different sources. • To encourage students to work collaboratively in teams to design and carry out experiments and Analyse data. • To increase students' understanding of fundamental Earth Science concepts such as rock formation, plate tectonics, soil formation, erosion, and climate change. • To instil in students an appreciation of the complexity and diversity of the Earth's systems and the importance of protecting and preserving our planet.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Design and conduct scientific investigations related to Earth and its processes using appropriate tools and techniques.

	CO2: Collect, Analyse, and interpret data from various sources, including field observations, laboratory analyses, and computer simulations. **CO3:** Communicate their findings and conclusions effectively through written reports, oral presentations, and visual aids. **CO4:** Apply their knowledge and skills to real-world problems related to Earth and Earth processes, such as natural hazards, climate change, and resource management. **CO5:** Have a comprehensive understanding of fundamental Earth Science concepts, including rock formation, plate tectonics, soil formation, erosion, and climate change, and will be able to apply this knowledge to new situations and problems.

Course Outline

Unit	Description
I	**Identification of rocks & minerals (Hand Specimen)** a) Rocks- Granite, Basalt, Dolerite, Shale, Sandstone, Limestone, Slate, Marble, Quartzite, Schist, Gneiss. b) Minerals- Talc, Bauxite, Mica, Quartz, Hematite, Galena.
II	**a. Toposheet interpretation.** **b. Use of GPS**
III	**Viva Voce**

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Physics and Chemistry of Environment Lab

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23

Semester	I
Course Title	Earth and Earth Surface Processes Lab
Course Code	EVS12205
Credit	2
Contact Hours (L-T-P)	0-0-3
Course Type	Practical
Course Objective	The objectives of this course are • To provide students with hands-on experience in conducting experiments related to environmental processes, including the atmosphere, hydrosphere, and lithosphere. • To develop skills in laboratory techniques, instrumentation, and data analysis related to environmental science. • To provide students with practical experience in using chemical and physical principles to investigate environmental issues, including pollution, climate change, and natural resource management. • To develop skills in scientific inquiry, experimental design, and problem-solving related to environmental science. • To foster critical thinking skills for evaluating and interpreting scientific data related to environmental issues, and effectively communicate scientific findings to a variety of audiences. • To provide students with an opportunity to work in teams to design, conduct, and report on environmental science experiments, and to develop skills in collaboration and project management.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Develop skills in laboratory techniques, instrumentation, and data analysis related to environmental science. **CO2:** Apply chemical and physical principles to investigate environmental issues, including pollution, climate change, and natural resource management.

	CO3: Analyse and interpret scientific data related to environmental issues, and effectively communicate scientific findings to a variety of audiences. **CO4:** Work effectively in teams to design, conduct, and report on environmental science experiments, and develop skills in collaboration and project management. **CO5:** Apply critical thinking skills to evaluate and solve problems related to environmental science and demonstrate an understanding of the scientific method and its applications to environmental issues.

Course Outline

Unit	**Description**
I	Acidity, Alkalinity (PA & TA), Total Hardness of water, Calcium Hardness of Water, DO, BOD, COD, Water holding capacity, TOC
II	Soil moisture, Soil pH, Soil electrical conductivity.
III	Viva Voce & Laboratory notebook.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Energy and Environment Lab

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	I

Course Title	Energy and Environment Lab
Course Code	EVS12206
Credit	2
Contact Hours (L-T-P)	0-0-3
Course Type	Practical
Course Objective	The objectives of this course are • To provide students with hands-on experience in conducting experiments related to environmental processes, including the atmosphere, hydrosphere, and lithosphere. • To develop skills in laboratory techniques, instrumentation, and data analysis related to environmental science. • To provide students with practical experience in using chemical and physical principles to investigate environmental issues, including pollution, climate change, and natural resource management. • To develop skills in scientific inquiry, experimental design, and problem-solving related to environmental science. • To foster critical thinking skills for evaluating and interpreting scientific data related to environmental issues, and effectively communicate scientific findings to a variety of audiences. • To provide students with an opportunity to work in teams to design, conduct, and report on environmental science experiments, and to develop skills in collaboration and project management.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Develop skills in laboratory techniques, instrumentation, and data analysis related to energy production, distribution, and consumption, and their impact on the environment. **CO2:** Apply scientific principles to investigate energy and environmental issues, including air pollution, greenhouse gas emissions, and energy efficiency.

	CO3: Analyse and interpret scientific data related to energy and environmental issues, and effectively communicate scientific findings to a variety of audiences. **CO4:** Work effectively in teams to design, conduct, and report on energy and environmental science experiments, and develop skills in collaboration and project management. **CO5:** Apply critical thinking skills to evaluate and solve problems related to energy and the environment, and demonstrate an understanding of the technological, economic, and social factors that influence energy use and the transition to a sustainable energy future.

Course Outline

Unit	Description
I	Calculation of energy efficiency from given data. EVS12206
II	Preparation of energy audit of a domestic unit and report submission.
III	Checklist for energy saving measures.
IV	Viva-voce & Laboratory Notebooks.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Program Outcome Vs Courses Mapping Table of Semester: II

Course Code	Course Name	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
EVS11207	Atmospheric Science and Climate Change	CO1	2	2	3	3	2	1	3	1	3	3
		CO2	3	1	1	2	2	2	2	2	2	2
		CO3	3	1	2	2	1	2	2	3	2	2
		CO4	2	2	1	1	2	3	2	1	1	1
		CO5	3	3	2	3	3	1	1	3	2	2
		CO	2.6	1.8	1.8	2.2	2	1.8	2	2	2	2
EVS11208	Water And Water Resources Management	**COs**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PSO1**	**PSO2**	**PSO3**
		CO1	2	2	1	3	2	1	2	1	1	2
		CO2	2	3	3	-	2	3	2	-	2	-
		CO3	3	2	1	2	3	1	2	2	2	2
		CO4	2	1	2	3	2	2	2	3	3	1
		CO5	3	2	2	3	3	1	2	2	-	2
EVS11209	Land and Soil Conservation and Management	CO1	2	2	3	3	2	1	2	1	3	3
		CO2	2	3	1	2	2	2	1	2	2	1
		CO3	3	2	2	2	2	2	2	2	2	2
		CO4	3	3	3	3	2	2	2	2	3	3
		CO5	3	2	1	2	3	3	1	3	1	2
		CO	2.6	2.4	2	2.4	2.2	2	1.6	2	2.2	2.2
EVS11105	AECC-2: Environmental Science and Energy Resources	CO1	2	2	3	3	2	1	2	1	3	3
		CO2	2	3	1	2	1	2	2	2	2	2
		CO3	3	2	2	2	2	2	3	2	2	2
		CO4	1	1	2	3	2	2	2	1	1	1
		CO5	3	2	2	1	3	1	1	3	1	2
		CO	2.2	2	2	2.2	2	1.6	2	1.8	1.8	2

Correlation level 1, 2 and 3 as defined below:

"1" – Slight (Low)
"2" - Moderate (Medium)
"3" – Substantial (High)
"-" – No correlation

School of Basic and Applied Sciences
BSc (Hons) Environmental Science
Batch: 2022-23
Semester: II

S. No.	Type of Course	Course Code	Course Title	Teaching Load				CREDITS
				L	**T**	**P**	**TOTAL**	
1	Core Theory	EVS11207	Atmospheric Science and Climate Change	4	0	0	4	4
2	Core Theory	EVS11208	Water And Water Resources Management	4	0	0	4	4
3	Core Theory	EVS11209	Land and Soil Conservation and Management	4	0	0	4	4
4	Core Theory	MTH11512	Mathematics for Environmental Modelling	3	1	0	4	4
5	GE Theory	CHM11153	Generic Elective Chemistry II	3	1	0	4	4
6	AECC Theory	EVS11105	AECC-2: Environmental Science and Energy Resources	2	0	0	2	2
7	Value Added Course	EIC11001	Venture Ideation	2	0	0	2	2
8	Core Practical	EVS12210	Atmospheric Science and Climate Change Lab	0	0	3	3	2
9	Core Practical	EVS12211	Water and Water Resources Management Lab	0	0	3	3	2
10	Core Practical	EVS12212	Land and Soil Conservation and Management Lab	0	0	3	3	2
11	GE Practical	CHM12154	Generic Elective Chemistry II Lab	0	0	3	3	2
			Total	**22**	**2**	**12**	**36**	**32**

Atmospheric science and Climate Change

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	II
Course Title	Atmospheric Science and Climate Change
Course Code	EVS11207
Credit	4
Contact Hours (L-T-P)	4-0-0
Course Type	Theory
Course Objective	The objectives of this course are • To provide students with a foundational understanding of atmospheric science, including the properties of the atmosphere, atmospheric circulation, and the processes that govern weather and climate. • To introduce students to the causes and effects of climate change, including the role of greenhouse gases, the impact of human activity on the climate system, and the potential consequences of global warming. • To familiarize students with the tools and techniques used to study climate change, including remote sensing, computer modeling, and data analysis. • To develop students' skills in critical thinking and scientific reasoning, and to foster their ability to evaluate scientific evidence and arguments related to climate change. • To explore the ethical and policy implications of climate change, including the role of science in policy-making, the potential for mitigation and adaptation measures, and the challenges of implementing effective climate policies. • To encourage students to engage in interdisciplinary thinking and collaborative problem-solving, and to foster

	their ability to communicate scientific concepts and findings to a variety of audiences. • To provide students with opportunities for independent research and inquiry, and to encourage their development as informed and engaged citizens with a deep understanding of the science and policy of climate change.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Understand the fundamental principles of atmospheric science, including the composition and structure of the atmosphere, atmospheric circulation, and the factors that influence weather and climate. **CO2:** Analyse the causes and consequences of climate change, including the role of greenhouse gases, the impact of human activity on the climate system, and the potential consequences of global warming. **CO3:** Develop skills in data analysis, computer modeling, and other tools used to study climate change, and apply these skills to investigate current and future climate trends. **CO4:** Evaluate the scientific evidence and arguments related to climate change and apply critical thinking skills to assess the validity of scientific claims and proposals related to climate policy. **CO5:** Understand the ethical and policy implications of climate change, including the challenges of implementing effective climate policies, the potential for mitigation and adaptation measures, and the role of science in policy-making.

Course Outline

Unit	Description
I	**Introduction:** Concepts of weather and climate; Evolution and development of Earth's atmosphere; atmospheric structure and composition; significance of atmosphere in making the Earth, the only biosphere; Milankovitch cycles, greenhouse effect and its effect on environment.
II	**Global energy balance:** Earth's energy balance; energy transfers in atmosphere; Earth's radiation budget; greenhouse gases (GHGs); greenhouse effect; global conveyor belt.
III	**Atmospheric circulation:** Movement of air masses; atmosphere and climate; air and sea interaction; southern oscillation; western disturbances; El Nino and La Nina; tropical cyclone; Indian monsoon and its development, changing monsoon in Holocene in the Indian subcontinent, its impact on agriculture and Indus valley civilization; effect of urbanization on microclimate; Asian brown clouds.

IV	**Meteorology and atmospheric stability:** Meteorological parameters (temperature, relative humidity, wind speed and direction, precipitation); atmospheric stability and mixing heights; temperature inversion; plume behavior; Gaussian plume model.
V	**Global warming and climate change:** Earth's climate through ages; trends of global warming and climate change; drivers of global warming and the potential of different greenhouse gases (GHGs) causing the climate change; atmospheric windows; impact of climate change on atmosphere, weather patterns, sea level rise, agricultural productivity and biological responses - range shift of species, CO_2 fertilization and agriculture; impact on economy and spread of human diseases.
VI	**Ozone layer depletion:** Ozone layer or ozone shield; importance of ozone layer; ozone layer depletion and causes; Chapman cycle; process of springtime ozone depletion over Antarctica; ozone depleting substances (ODS); effects of ozone depletion; mitigation measures and international protocols.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text and Reference Books:

1. Barry, R. G. 2003. Atmosphere, Weather and Climate. Routledge Press, UK.
2. Gillespie, A. 2006. Climate Change, Ozone Depletion and Air Pollution: Legal Commentaries with Policy and Science Considerations. Martinus Nijhoff Publishers.
3. Hardy, J.T. 2003. Climate Change: Causes, Effects and Solutions. John Wiley & Sons.
4. Harvey, D. 2000. Climate and Global Climate Change. Prentice Hall.
5. Manahan, S.E. 2010. Environmental Chemistry. CRC Press, Taylor and Francis Group.
6. Maslin, M. 2014. Climate Change: A Very Short Introduction. Oxford Publications.
7. Mathez, E.A. 2009. Climate Change: The Science of Global Warming and our Energy Future. Columbia University Press.
8. Mitra, A.P., Sharma, S., Bhattacharya, S., Garg, A., Devotta, S. & Sen, K. 2004. Climate Change and India. Universities Press, India.

9. Philander, S.G. 2012. Encyclopedia of Global Warming and Climate Change (2nd edition). Sage Publications.

Water And Water Resources Management

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	II
Course Title	Water And Water Resources Management
Course Code	EVS11208
Credit	4
Contact Hours (L-T-P)	4-0-0
Course Type	Theory
Course Objective	The objectives of this course are • To provide students with an understanding of the importance of water resources and the challenges associated with managing them sustainably. • To introduce students to the principles and practices of water resources management, including the concepts of water governance, water allocation, and water quality management. • To provide students with an understanding of the hydrological cycle, including surface water and groundwater resources, and the interactions between water resources and the natural environment. • To enable students to apply hydrological and engineering principles to design water supply, treatment, and distribution systems. • To provide students with an understanding of the social, economic, and political factors that influence water

	resources management, including water rights, stakeholder engagement, and policy development. • To develop students' skills in data collection, analysis, and interpretation related to water resources, including the use of GIS and other tools for spatial analysis. • To foster an understanding of the importance of water conservation and sustainability, including the promotion of water-saving behaviors and the use of water-efficient technologies. • To encourage students to think critically and creatively about solutions to water resources challenges, including the development of innovative technologies and approaches. • To prepare students for careers in water resources management, including government agencies, non-governmental organizations, and the private sector.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Describe the hydrological cycle and the interactions between water resources and the natural environment, and apply this knowledge to the design and management of water supply and treatment systems. **CO2:** Analyse and interpret data related to water resources, including hydrological data, water quality data, and socio-economic data, using appropriate tools and techniques, such as GIS and statistical analysis. **CO3:** Explain the principles and practices of water resources management, including the concepts of water governance, water allocation, and water quality management, and apply these principles to real-world problems and case studies. **CO4:** Identify and assess the social, economic, and political factors that influence water resources management, including water rights, stakeholder engagement, and policy development, and develop strategies for effective stakeholder engagement and communication. **CO5:** Design and implement water resources management plans and projects that are sustainable, equitable, and responsive to the needs of different stakeholders, and evaluate the effectiveness of these plans and projects based on environmental, social, and economic criteria.

Course Outline

Unit	Description
I	**Introduction:** Sources and types of water; hydrological cycle; precipitation, runoff, infiltration, evaporation, evapotranspiration; classification of water resources (oceans, rivers, lakes and wetlands).'Global water crisis.
II	**Properties of water:** Physical: temperature, colour, odour, total dissolved solids and total suspended solids; Chemical: major inorganic and organic constituents, dissolved gases, DO, COD, BOD, acidity and alkalinity, electrical conductivity, sodium adsorption ratio
III	**Surface and subsurface water:** Introduction to surface and ground water; surface and ground water pollution; water table and piezometric surface; vertical distribution of water; classification of sub-surface lithology and types of aquifers; river structure and patterns; rainwater harvesting and artificial recharge; watershed management; classification of watershed; importance of watershed
IV	**Wetlands and their management:** Definition of a wetland; types of wetlands (fresh water and marine); ecological significance of wetlands; threats to wetlands; wetland conservation and management; Ramsar Convention, 1971; major wetlands of India.
V	**Marine resource management:** Marine resources; commercial use of marine resources; threats to marine ecosystems and resources; marine ecosystem and resource management (planning approach, construction techniques and monitoring of coastal zones); Saline water intrusion and its management.
VI	**Water resource in India:** Water resources of India, Demand for water (agriculture, industrial, domestic); water crisis; overuse and depletion of surface and ground water resources; water quality standards in India; hot spots of surface water; role of state in water resources management.
VII	**Water resources conflicts:** Water resources and sharing problems, case studies on Kaveri and Krishna river water disputes; Multipurpose river valley projects in India and their environmental and social impacts; case studies of dams - Narmada and Tehri dam – social and ecological losses versus economic benefits; International conflicts on water sharing between India and her neighbours; agreements to resolve these conflicts.
VIII	**Major laws and treaties:** National water policy; The Easement Act, 1882, Water pollution (control and prevention) Act 1974; Indus water treaty; West Bengal Ground Water Resources (Management, Control and Regulation) Act, 2005, Ganges water treaty; Teesta water treaty; Indian River linking project: ecological and economic impacts.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text and Reference Books:

1. Bansil, P.C. 2004. Water Management in India. Concept Publishing Company, India.
2. Brebbia, C.A. 2013. Water Resources Management VII. WIT Press.
3. CEA. 2011. Water Resources and Power Maps of India. Central Board of Irrigation & Power.
4. Grumbine, R.E. & Pandit, M.K. 2013. Threats from India's Himalaya dams. Science 339:36-37.
5. Loucks, D.P., Stedinger, J.R. & Haith, D. A. 1981. Water Resource Systems Planning and Analysis. Englewood Cliffs, NJ, Prentice Hall.
6. Mays, L.W. 2006. Water Resources Sustainability. The McGraw-Hill Publications.
7. Schward& Zhang, 2003. Fundamentals of Groundwater. John Willey and Sons.
8. Souvorov, A.V. 1999. Marine Ecologonomics: The Ecology and Economics of Marine Natural Resource Management. Elsevier Publications.
9. Vickers, A. 2001. Handbook of Water Use and Conservation. Water Plow Press.

Land and Soil Conservation and Management

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	II
Course Title	Land and Soil Conservation and Management
Course Code	EVS11209
Credit	4
Contact Hours (L-T-P)	4-0-0
Course Type	Theory

Course Objective	The objectives of this course are • Understanding the importance of soil and land as natural resources and their role in sustaining ecosystems and human livelihoods. • Developing knowledge about the physical, chemical, and biological properties of soil, as well as the factors that affect soil health and productivity. • Learning about the different types of land degradation and soil erosion, their causes, and the impacts they have on the environment and human communities. • Examining the historical and current practices of soil and land management, including traditional, indigenous, and modern techniques. • Identifying the challenges and opportunities in managing soil and land resources sustainably, including balancing economic, social, and environmental factors. • Developing skills in designing and implementing effective soil and land conservation and management strategies, including soil erosion control, soil restoration, and sustainable land use planning. • Understanding the role of policy and governance in supporting sustainable land and soil management, including national and international frameworks for conservation and management. • Learning about the role of stakeholders, including local communities, farmers, and landowners, in soil and land conservation and management, and the importance of stakeholder engagement and participation in decision-making processes.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Evaluate the physical, chemical, and biological properties of soil and land, and understand the factors that affect soil health and productivity. **CO2:** Analyse the various types of land degradation and soil erosion, including their causes and impacts on the environment and human communities. **CO3:** Develop effective strategies for soil and land conservation and management, including soil erosion control, soil restoration, and sustainable land use planning. **CO4:** Understand the role of policy and governance in supporting sustainable soil and land management, including

	national and international frameworks for conservation and management. **CO5:** Critically evaluate the socio-economic and political context in which soil and land management takes place, including the role of stakeholders and the importance of stakeholder engagement and participation in decision-making processes.

Course Outline

Unit	Description
I	**Introduction:** Land as a resource, soil health; ecological and economic importance of soil; types and causes of soil degradation; impact of soil loss and soil degradation on agriculture and food security; need for soil conservation and restoration of soil fertility.
II	**Fundamentals of soil science:** Soil formation; soil components; classification of soil; soil architecture; physical properties of soil; soil texture; soil water holding capacity; soil forming factors, soil development; soil temperature; soil colloids; soil acidity and alkalinity; soil salinity and sodicity; soil organic matter; micronutrients of soil; nitrogen, sulphur, potassium and phosphorus economy of soil; soil biodiversity; soil taxonomy maps.
III	**Soil degradation - causes:** Soil resistance and resilience; nature and types of soil erosion; non-erosive and erosive soil degradation; losses of soil moisture and its regulation; nutrient depletion; soil pollution due to mining and mineral extraction, industrial and urban development, toxic organic chemicals, and organic contaminants in soils; fertilizers and fertilizer management; recycling of soil nutrients.
IV	**Landuse/Land cover changes and land degradation:** Land resources: types and evaluation; biological and physical phenomena in land degradation; visual indicators of land degradation; drivers of land degradation - deforestation, desertification; habitat loss, loss of biodiversity; range land degradation; land salinization; human population pressure, poverty, socio-economic and institutional factors; drivers of land use and land cover change in major geographic zones and biodiverse regions with particular reference to the Himalaya and the Western Ghats.
V	**Costs of land degradation:** Economic valuation of land degradation; onsite and offsite costs of land degradation; loss of ecosystem services; effects on farming communities; effects on food security; effects on nutrient cycles; future effects of soil degradation; emerging threats of land degradation to developing countries.
VI	**Soil conservation and Management of land degradation:** Soil conservation; Sustainable land use planning; role of databases and data analysis in landuse planning control and management; land tenure and land policy; legal, institutional, and sociological factors; participatory land degradation assessment; integrating land degradation assessment into conservation, land reclamation.

Evaluation:

Mode of Evaluation	Theory

Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text and Reference Books:

1. Brady, N.C. & Well, R.R. 2007.The Nature and Properties of Soils (13th edition), Pearson Education Inc.
2. Gadgil, M. 1993. Biodiversity and India's degraded lands. Ambio 22: 167-172.
3. Johnson, D.L. 2006. Land Degradation (2nd edition). Rowman& Littlefield Publishers.
4. Marsh, W. M. & Dozier,J. 1983. Landscape Planning: Environmental Applications. John Wiley and Sons.
5. Oldeman, L. R. 1994. The global extent of soil degradation. Soil resilience and sustainable land use, 9. (http://library.wur.nl/isric/fulltext/isricu_i26803_001.pdf).
6. Pandit, M.K. et. al. 2007. Unreported yet massive deforestation driving loss of endemic biodiversity in Indian Himalaya. Biodiversity Conservation 16: 153-163.
7. Pandit, M.K. & Kumar, V. 2013. Land use and conservation challenges in Himalaya: Past, present and future. In: Sodhi, N.S., Gibson, L. & Raven, P.H. Conservation Biology: Voices from the Tropics. pp. 123-133. Wiley-Blackwell, Oxford, UK .
8. Peterson, G. D., Cumming, G. S. & Carpenter, S. R. 2003. Scenario planning: a tool for conservation in an uncertain world. Conservation Biology 17: 358-366.
9. Scherr, S. J. 1999. Soil degradation: A threat to developing-country food security by 2020? (Vol. 27). International Food Policy Research Institute.

Mathematics for Environmental Modelling

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	II

Course Title	Land and Soil Conservation and Management
Course Code	MTH11512
Credit	4
Contact Hours (L-T-P)	3-1-0
Course Type	Theory
Course Objective	The objectives of this course are • Developing mathematical skills for environmental modelling, including calculus, linear algebra, and differential equations. • Understanding the principles of numerical methods for solving environmental problems, including finite difference, finite element, and other methods. • Applying mathematical techniques to model physical, chemical, and biological processes in environmental systems, including atmospheric, aquatic, and terrestrial environments. • Learning how to validate and interpret environmental models using statistical methods and sensitivity analysis. • Understanding the importance of uncertainty analysis and risk assessment in environmental modelling. • Developing skills in using computational tools and software for environmental modelling, including programming languages. • Learning how to communicate scientific findings effectively using visual aids such as graphs, charts, and maps. • Understanding the ethical and social implications of environmental modelling, including the potential impact on ecosystems, human health, and policy decisions.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Develop proficiency in mathematical techniques such as calculus, linear algebra, and differential equations for modelling environmental systems. **CO2:** Apply numerical methods such as finite difference, finite element, and other methods to solve environmental problems and interpret the results.

	CO3: Create models of physical, chemical, and biological processes in environmental systems, including atmospheric, aquatic, and terrestrial environments. **CO4:** Validate and interpret environmental models using statistical methods and sensitivity analysis. **CO5:** Use computational tools and software, including programming languages, to build and Analyse environmental models and effectively communicate scientific findings using visual aids such as graphs, charts, and maps.

Course Outline

Unit	Description
I	**Basic Algebra:** Real valued functions, classification and graphs of real valued functions, surd, indices, exponentials and logarithms, quadratic equations, system of linear equations with two variables, partial fractions.
II	**Matrix Algebra**: Introduction to matrices and determinants, types of matrices, matrix operations, transpose, addition, subtraction, matrix multiplication, determinants, singular and non-singular matrices, minors, cofactors, adjoint, inverse, solution of system of linear equations using matrix inversion method and Cramer's Rule
III	**Differentiation:** Definition of derivative, rules of differentiation (without Proof), derivatives of algebraic, trigonometric, exponential and logarithmic functions, Chain rule, second order derivative with examples, maxima/minima of functions, and its applications. **Integration:** Definition of integration, standard formulas, method of substitution, integration by parts, definite integrals.
IV	**Differential Equations:** Some basic definitions, formation of differential equations, order and degree, equations in separable form, homogeneous equations, exact equations, linear differential equations, application of first order differential equations, concept of higher order differential equations.
V	**Applications of basic statistics in Environmental Science**

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text and Reference Books:

1. B. S. Grewal, Higher Engineering Mathematics, Khanna Publishers

2. P. K. Sharma, Remedial Mathematics, Nirali Prakaschan
3. N. Piskunov, Differential and Integral Calculus, Vol II, CBS Publishers and Distributors

Atmospheric Science and Climate Change Lab

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	II
Course Title	Atmospheric Science and Climate Change Lab
Course Code	EVS12210
Credit	2
Contact Hours (L-T-P)	0-0-3
Course Type	Practical
Course Objective	The objectives of this course are • Understanding the fundamental principles of atmospheric science, including the structure and composition of the atmosphere, atmospheric dynamics, and weather systems. • Learning how to use scientific instruments to measure and Analyse atmospheric data, including temperature, pressure, humidity, and wind speed and direction. • Developing an understanding of climate change and its impacts on the atmosphere, oceans, and ecosystems. • Understanding the processes that contribute to climate change, including greenhouse gas emissions and feedback mechanisms. • Learning how to use computer models to simulate and predict atmospheric and climate conditions. • Developing skills in data analysis, scientific writing, and effective communication of atmospheric and climate science concepts to diverse audiences.

	• Understanding the ethical and political dimensions of climate change and the role of science in informing policy decisions. • Conducting experiments and analyzing data to investigate atmospheric and climate phenomena, such as the greenhouse effect, El Niño, and the impacts of air pollution on climate. • Collaborating with peers on group projects and presentations to develop teamwork and communication skills.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Develop a comprehensive understanding of the fundamental principles of atmospheric science, including the composition and structure of the atmosphere, atmospheric dynamics, and weather systems. **CO2:** Gain proficiency in using scientific instruments to measure and analyse atmospheric data, such as temperature, pressure, humidity, and wind speed and direction. **CO3:** Understand the impacts of climate change on the atmosphere, oceans, and ecosystems, and identify the processes that contribute to climate change, including greenhouse gas emissions and feedback mechanisms. **CO4:** Gain proficiency in using computer models to simulate and predict atmospheric and climate conditions and develop the ability to Analyse and interpret the resulting data. **CO5:** Develop strong scientific writing and communication skills, including the ability to effectively communicate atmospheric and climate science concepts to diverse audiences, and collaborate effectively with peers on group projects and presentations.

Course Outline

Unit	Description
I	Estimation of atmospheric pressure, relative humidity, rainfall, insolation, wind speed, and light intensity (Lux meter).
II	Viva-voce & Laboratory notebook.

Evaluation:

Mode of Evaluation	Theory

Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Water and Water Resources Management Lab

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	II
Course Title	Water and Water Resources Management Lab
Course Code	EVS12211
Credit	2
Contact Hours (L-T-P)	0-0-3
Course Type	Practical
Course Objective	The objectives of this course are • Understanding the physical, chemical, and biological properties of water, and the importance of water resources management in ensuring sustainable development. • Learning how to use scientific instruments and techniques to measure and Analyse water quality parameters, such as pH, dissolved oxygen, and turbidity. • Developing an understanding of the principles of hydrology, including precipitation, evaporation, and runoff, and the impacts of human activities on the water cycle. • Understanding the principles of water treatment and distribution, including the use of filtration, disinfection, and distribution systems to ensure safe and reliable water supplies. • Developing skills in data analysis, scientific writing, and effective communication of water and water resources management concepts to diverse audiences.

	• Understanding the ethical and political dimensions of water resources management, including issues of access, equity, and sustainability. • Conducting experiments and field studies to investigate water quality and quantity issues, such as the impacts of land use change on water resources. • Collaborating with peers on group projects and presentations to develop teamwork and communication skills.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Understand the physical, chemical, and biological properties of water, and the importance of water resources management in ensuring sustainable development. **CO2:** Develop skills in using scientific instruments and techniques to measure and Analyse water quality parameters, such as pH, dissolved oxygen, and turbidity. **CO3:** Understand the principles of hydrology, including precipitation, evaporation, and runoff, and the impacts of human activities on the water cycle. **CO4:** Develop an understanding of the principles of water treatment and distribution, including the use of filtration, disinfection, and distribution systems to ensure safe and reliable water supplies. **CO5:** Develop strong scientific writing and communication skills, including the ability to effectively communicate atmospheric and climate science concepts to diverse audiences, and collaborate effectively with peers on group projects and presentations.

Course Outline

Unit	Description
I	**Chemical characteristics of water:** Turbidity, pH, Electrical conductivity, Salinity (through Chloride Estimation), Dissolved oxygen, BOD, COD, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Iron.
II	Viva-voce & Laboratory notebook.

Evaluation:

Mode of Evaluation	Theory

Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Land Management and Soil Conservation Lab

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	II
Course Title	Land Management and Soil Conservation Lab
Course Code	EVS12212
Credit	2
Contact Hours (L-T-P)	0-0-3
Course Type	Practical
Course Objective	The objectives of this course are • Understand the physical, chemical, and biological properties of soil, and their importance in agriculture and natural ecosystems. • Develop practical skills in using scientific instruments and techniques to measure and Analyse soil properties. • Understand the principles of soil and water conservation, including erosion control, nutrient management, and sustainable land use practices. • Gain experience in conducting soil surveys and land use planning to inform effective land management decisions. • Develop effective communication skills for presenting scientific data and research findings related to soil and land management.
Course Outcome (CO)	After completion of this course, students will be able to:

	CO1: Understand the physical, chemical, and biological properties of soil, and the importance of soil conservation in ensuring sustainable land use. **CO2:** Develop skills in using scientific instruments and techniques to measure and Analyse soil properties, such as soil texture, pH, and nutrient content. **CO3:** Understand the principles of soil and water conservation, including erosion control, nutrient management, and sustainable land use practices. **CO4:** Develop an understanding of the principles of land management, including soil survey, land use planning, and the role of agriculture and forestry in land management. **CO5:** Develop strong data analysis, scientific writing, and communication skills, including the ability to effectively communicate soil and land management concepts to diverse audiences, and collaborate effectively with peers on group projects and presentations.

Course Outline

Unit	Description
I	**Chemical characteristics of Soil:** Soil Organic Carbon, Water Holding Capacity, Determination of Soil carbonate and Bicarbonate, Available NPK of Soil (Demonstration only).
II	Viva-voce & Laboratory notebook.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Program Outcome Vs Courses Mapping Table of Semester: III

Course Code	Course Name	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
EVS11213	Ecology and Ecosystems	CO1	2	2	3	3	2	1	3	1	3	3
		CO2	3	2	1	2	2	2	2	2	2	2
		CO3	3	1	2	2	1	2	2	3	2	2
		CO4	1	2	3	1	2	3	2	1	1	1
		CO5	3	3	2	3	3	1	1	3	2	2
		CO	2.4	2	2.2	2.2	2	1.8	2	2	2	2
EVS11214	Evolutionary Biology	**COs**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PSO1**	**PSO2**	**PSO3**
		CO1	2	2	1	3	2	2	2	1	1	2
		CO2	1	3	3	-	2	3	2	-	2	-
		CO3	3	2	3	2	3	1	2	2	2	2
		CO4	2	1	2	3	2	2	2	3	3	1
		CO5	3	2	2	3	3	1	2	2	-	2
		CO	2.2	2	2.2	2.75	2.4	1.8	2	2	2	1.75

Correlation level 1, 2 and 3 as defined below:

"1" – Slight (Low)
"2" - Moderate (Medium)
"3" – Substantial (High)
"-" – No correlation

School of Basic and Applied Sciences
BSc (Hons) Environmental Science
Batch: 2022-23
Semester: III

S. No.	Type of Course	Course Code	Course Title	Teaching Load				CREDITS
				L	**T**	**P**	**TOTAL**	
1	Core Theory	EVS11213	Ecology and Ecosystems	4	0	0	4	4
2	Core Theory	EVS11214	Evolutionary Biology	4	0	0	4	4
3	Core Theory	GEO11001	Generic Elective Geography-I	4	0	0	4	4
4	Core Practical	EVS12215	Ecology and Ecosystems Lab	0	0	3	3	2
5	Core Practical	EVS12216	Evolutionary Biology Lab	0	0	3	3	2
6	Core Practical	GEO12002	Generic Elective Geography-I Lab	0	0	4	4	2
7	Value Added Course	IDP14001	Inter-Disciplinary Project	-	3	-	3	3
8	Value Added Course	SOC14100	Community Service	-	1	-	1	1
9	SEC Theory	EVS11217	SEC A1: Natural Hazards & Disaster Management	2	0	0	2	2
		OR						
		EVS11218	SEC A2: Wildlife Management					
			Total	**14**	**4**	**10**	**28**	**24**

Ecology and Ecosystems

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	III
Course Title	Ecology and Ecosystems
Course Code	EVS11213
Credit	4
Contact Hours (L-T-P)	4-0-0
Course Type	Theory
Course Objective	The objectives of this course are • Understand the fundamental principles of ecology and the relationships between living organisms and their environment. • Learn to identify and classify different types of ecosystems and understand the factors that shape their characteristics and functions. • Gain knowledge of the biotic and abiotic factors that influence the distribution and abundance of species in ecosystems. • Develop skills in experimental design and data analysis in ecology, including sampling techniques and statistical methods. • Understand the impacts of human activities on ecosystems, and the principles and practices of conservation biology and ecosystem management. • Develop effective communication skills for presenting scientific data and research findings related to ecology and ecosystems.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1:** Explain the basic principles of ecology and the relationships between living organisms and their environment.

	CO2: Analyse the biotic and abiotic factors that influence the distribution and abundance of species in ecosystems. **CO3:** Apply experimental design and data analysis techniques to ecological research questions, including sampling and statistical methods. **CO4:** Evaluate the impacts of human activities on ecosystems, and the principles and practices of conservation biology and ecosystem management. **CO5**: Communicate scientific data and research findings related to ecology and ecosystems effectively, both in written and oral formats.

Course Outline

Unit	Description
I	**Ecosystem Ecology:** Basic concepts and definitions: biosphere, ecology, landscape, ecosystems, ecosystem stability, resistance and resilience; concepts of autecology and synecology; Biogeographic zones in India and concepts of Protected Area Network; Types of ecosystem: forest, grassland, lentic, lotic, estuarine, marine, desert, wetlands; Aquatic ecology Biological: phytoplankton, phytobenthos, zooplankton, macro-invertebrates and microbes; ecosystem structure and function; abiotic and biotic components of ecosystem; ecosystem boundary; ecosystem function; ecosystem metabolism; primary production and models of energy flow; secondary production and trophic efficiency; ecosystem connections: food chain, food web; detritus pathway of energy flow and decomposition processes; ecological efficiencies; ecological pyramids: pyramids of number, biomass, and energy; Carbon cycle; nitrogen cycle; phosphorus cycle; sulphur cycle; hydrological cycle; nutrient cycle models; ecosystem input of nutrients; biotic accumulation; ecosystem losses; nutrient supply and uptake; role of mycorrhizae; decomposition and nutrient release; nutrient use efficiency; nutrient budget; nutrient conservation strategies.
II	**Ecology of individuals:** Ecological amplitude; Liebig's Law of the Minimum; Shelford's Law of Tolerance; phenotypic plasticity; ecotypes; ecoclines; acclimation; ecological niche; types of niche: Eltonian niche, Hutchinsonian niche, fundamental niche, realized niche; niche breadth; niche partitioning; niche differentiation; thermoregulation; strategies of adaptation in plants and animals.
III	**Ecology of populations**: Concept of population and meta-population; characteristics of population density, dispersion, natality, mortality, life tables, survivorship curves, age structure; population growth: geometric, exponential, logistic, density-dependent; population fluctuations; population interaction and regulations; r- and K-selection; limits to population growth; deterministic and stochastic models of population

	dynamics; Population dispersion, fluctuations, interaction, distribution, regulations; ruderal, competitive and stress-tolerance strategies,
IV	**Community Ecology and Ecological succession:** Discrete versus continuum community view; community structure and organization: physiognomy, sociability, species associations, periodicity, biomass, stability, keystone species, ecotone and edge effect; Concepts of species diversity; Concepts of stability and diversity in ecosystem; ecological succession: primary and secondary successions, concepts of allogenic and autogenic succession, models and types of successions, Facilitation, Tolerance and Inhibition; Concept of sere, climax community concepts, examples of succession (aquatic and terrestrial).
V	**Behavioral Ecology**: Learning and Imptinting, types of examples; Sexual Selection, Red Queen Hypothesis, Handicap Principle; Basic concepts of sociobiology; Basis of kin and group selection; Reciprocal Altruism.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text & References Books:

1. Groom. B. &Jenkins. M. 2000.Global Biodiversity: Earth's Living Resources in the 21 st Century. World Conservation Press, Cambridge, UK.
2. Gurevitch, J., Scheiner, S. M., &Fox, G. A. 2002. The Ecology of Plants. Sinauer associates incorporated.
3. Loreau, M. &Inchausti, P. 2002. Biodiversity and Ecosystem functioning: Synthesis and Perspectives. Oxford University Press, Oxford, UK.
4. Odum, E.P. 1971. Fundamentals of Ecology. W.B. Sounders.
5. Pandit, M.K., White, S.M.&Pocock, M.J.O. 2014. The contrasting effects of genome size, chromosome number and ploidy level on plant invasiveness: a global analysis. New Phytologist. 203: 697-703.
6. Pimentel, D. (Ed.). 2011. Biological invasions: Economic and environmental costs of alien plant, animal, and microbe species. CRC Press.

7. Singh, J.S., Singh, S.P. &Gupta, S.R. 2006. Ecology, Environment and Resource Conservation. Anamaya Publications.
8. Wilson, E. O. 1985. The Biological Diversity Crisis. BioScience 35: 700-706.

Evolutionary biology

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	III
Course Title	Evolutionary biology
Course Code	EVS11214
Credit	4
Contact Hours (L-T-P)	4-0-0
Course Type	Theory
Course Objective	The objectives of this course are • Develop an understanding of the basic principles of evolution and the historical development of evolutionary theory. • Understand the mechanisms of evolution, including natural selection, genetic drift, gene flow, and mutation. • Develop the ability to critically evaluate scientific literature and apply evolutionary theory to diverse biological systems and phenomena. • Learn to use phylogenetic methods to infer evolutionary relationships among organisms and interpret evolutionary history. • Understand the role of genetics and genomics in evolutionary biology, including the study of molecular evolution and the genomic basis of adaptation.

	• Explore the relevance of evolutionary biology to current issues in fields such as medicine, agriculture, conservation, and environmental science.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Understand the key concepts and principles of evolutionary biology, including natural selection, genetic drift, gene flow, and speciation. **CO2:** Develop the ability to critically Analyse and interpret scientific data and literature in the context of evolutionary biology. **CO3:** Use phylogenetic methods to infer evolutionary relationships among organisms and interpret evolutionary history. **CO4:** Gain an understanding of the genomic basis of evolution, including the study of molecular evolution, gene regulation, and the evolution of development. **CO5:** Understand the role of genetics and genomics in evolutionary biology, including the study of molecular evolution and the genomic basis of adaptation.

Course Outline

Unit	Description
I	**Emergence of life and the evolutionary path:** Paleo-records of diversity and diversification; Paleontology and evolutionary History; Geological time scale; major events in the evolutionary time scale; Origin of life: abiotic synthesis of basic biological molecules, micelles, monomers and polymers; Oparin-Haldane hypothesis; study of Urey and Miller's experiment of early life on earth; the first cell and unicellular evolution.
II	**Basics of cellular organization and metabolism:** A. Prokaryotes cell and life processes; Cellular organization and functions, outer membrane of Gram-negative bacteria and its relevance in pathogenicity, anaerobic metabolism and electron transport, motility and quorum sensing, B. Evolution of eukaryotic metabolism; Origins of multicellular organisms. Eukaryotic cell organization, Membrane structure & transport; Anabolic and catabolic processes: photosynthesis and aerobic metabolism. Role of Mitochondria in eukaryotic metabolism energetic, Cell cycle - An overview of cell cycle and Programmed cell death (Apoptosis).
III	**Molecular evolution:** Neutral evolution; molecular divergence and molecular clocks; classification and identification; protein and nucleotide sequence analysis; origin of new genes and proteins; gene duplication and divergence. Concepts of populations, gene pool, gene frequency; concepts and rate of change in gene frequency through natural selection, Mendelism; spontaneity of mutations; migration and genetic drift;

	Concept of Kettlewall; Hardy-Weinberg Law; adaptive radiation; isolating mechanisms; speciation (allopatric, sympatric, peripatric and parapatric); convergent and divergent evolution; Concept of selection, Directional, Stabilising and Disruptive; sexual selection; coevolution.
IV	**Biogeography of Species evolution:** Species' habitats; environment and niche concepts; biotic and abiotic determinants of communities; species-area relationships; concept of rarity and commonness; Island Biogeography theory; geography of diversification and invasion; biogeographical rules – Gloger's rule, Bergmann's rule, Allen's rule, Geist rule; biogeographical realms and their fauna; endemic, rare, exotic, and cosmopolitan species. De Vries' mutation theory, Synthetic theory of evolution; Concept of stasis; Punctuated Equilibrium Theory; Lamarck's concept of evolution; Darwin's Evolutionary Theory: variation, adaptation, struggle, fitness and natural selection.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text and Reference Books:

1. Lodish, H.F., Baltimore, D., Berk, A. Zipursky, S.L. Matsudiara, P. & Darnell, J. 1995. Molecular Cell Biology. W.H. Freeman.
2. Thorne, J. L., Kishino, H., & Painter, I. S. 1998. Estimating the rate of evolution of the rate of molecular evolution. Molecular Biology and Evolution 15: 1647-1657.
3. Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton, 2008. Prescott, Harley, and Klein's microbiology. 7th ed. McGraw-Hill.
4. Futuyma, D.J. 2009. Evolution (2nd edition). Sinauer Associates.
5. Gillespie, J. H. 1991. The Causes of Molecular Evolution. Oxford University Press.
6. Graur, D. & Li, W.H. 1999. Fundamentals of Molecular Evolution (2nd edition). Sinauer Associates.
7. Kimura, M. 1984. The Neutral Theory of Molecular Evolution. Cambridge University Press.

8. Nei, M. & Kumar, S. 2000. Molecular Evolution and Phylogenetics. Oxford University Press.
9. Thorne, J. L., Kishino, H., & Painter, I. S. 1998. Estimating the rate of evolution of the rate of molecular evolution. Molecular Biology and Evolution.

Ecology and Ecosystems Lab

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	III
Course Title	Ecology and Ecosystems Lab
Course Code	EVS12215
Credit	2
Contact Hours (L-T-P)	0-0-3
Course Type	Practical
Course Objective	The objectives of this course are • Gain hands-on experience with ecological field methods and data collection techniques. • Develop an understanding of the principles and theories of ecosystem ecology and their practical application in the field. • Learn to identify and classify species of plants, animals, and microbes in the field and laboratory. • Develop skills in statistical analysis and data visualization for ecological data sets. • Learn to design and carry out ecological experiments, and interpret and report on the results. • Understand the role of ecological research in addressing contemporary environmental issues and policy decisions.
Course Outcome (CO)	After completion of this course, students will be able to:

	CO1: Develop proficiency in using field methods and data collection techniques in the context of ecological research. **CO2:** Apply ecological theory and principles to design and execute experiments to investigate questions related to ecosystems and the environment. **CO3:** Learn to identify and classify species of plants, animals, and microbes, and understand their ecological roles and interactions within ecosystems. **CO4:** Analyse and interpret ecological data using statistical methods and data visualization tools. **CO5:** Gain an understanding of the role of ecological research in addressing environmental challenges and policy decisions.

Course Outline

Unit	**Description**
I	Field study in ecology using both qualitative and quantitative studies (Checklist/ Quadrate/ Transect) from any one of the following bio-geographical area (coastal/ forest/ Hills) with report submission.
II	Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided.
III	Biological parameters of water: Identification of Plankton, Neuston, Nekton, Periphyton, Benthos.
IV	Study and verification of Hardy-Weinberg Law by chi square analysis.
V	Viva-voce.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Evolutionary biology Lab

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	III
Course Title	Evolutionary biology Lab
Course Code	EVS12216
Credit	2
Contact Hours (L-T-P)	0-0-3
Course Type	Practical
Course Objective	The objectives of this course are • Gain hands-on experience with laboratory techniques commonly used in evolutionary biology research. • Apply evolutionary theory to design and carry out experiments to investigate questions related to evolution. • Develop proficiency in data collection, analysis, and interpretation using statistical methods and software commonly used in evolutionary biology research. • Develop skills in scientific writing and presentation by producing a scientific report and presenting results in a professional manner. • Explore the role of evolutionary biology in addressing contemporary societal issues such as the evolution of antibiotic resistance or the impacts of climate change on evolutionary processes.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Demonstrate an understanding of evolutionary theory and its applications in biology. **CO2:** Develop proficiency in laboratory techniques commonly used in evolutionary biology research. **CO3:** Apply statistical methods and data analysis tools to evolutionary biology research questions.

	CO4: Communicate scientific findings in written and oral formats, using appropriate scientific language and formatting. **CO5:** Critically evaluate and interpret scientific literature in the field of evolutionary biology.

Course Outline

Unit	Description
I	Numerical problems on pedigree and population genetics; Visit to the museum.; Hardy-Weinberg Law and its applications; Determination of change in allelic frequency due to natural selection, mutation and genetic drift; based on data provided from suggested readings (Sl. 5 & 6).
II	Laboratory Notebook and Viva-voce.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

SEC A1: Natural Hazards and Disaster Management

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	III
Course Title	SEC A1: Natural Hazards and Disaster Management
Course Code	EVS11217
Credit	2
Contact Hours (L-T-P)	2-0-0

Course Type	Theory
Course Objective	The objectives of this course are • To understand the causes and mechanisms of natural hazards, including earthquakes, tsunamis, hurricanes, floods, and wildfires. • To identify the key factors that make communities vulnerable to natural hazards, including physical, social, economic, and political factors. • To explore the principles and strategies of disaster risk reduction, including preparedness, mitigation, response, and recovery. • To develop skills in hazard assessment and risk analysis, using a range of tools and methods, including GIS, remote sensing, and statistical analysis. • To examine the role of science, technology, and policy in disaster management, and their integration with community-based approaches. • To understand the ethical and social dimensions of natural hazards and disaster management, including issues of equity, justice, and community resilience. • To apply knowledge and skills learned in the course to real-world case studies, including recent disasters and emergencies, and develop effective disaster management plans.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Explain the causes and characteristics of various natural hazards, such as earthquakes, floods, and hurricanes, and assess their potential impacts on human populations and the environment. **CO2:** Analyse the social, economic, and environmental factors that contribute to community vulnerability to natural hazards and evaluate the effectiveness of various strategies for reducing disaster risk and building resilience. **CO3:** Develop emergency management plans and procedures for different types of natural hazards and demonstrate proficiency in the use of tools and technologies for hazard assessment, warning, and response. **CO4:** Critically evaluate the role of governments, NGOs, and other stakeholders in natural hazard and disaster management, and assess the ethical and political dimensions of disaster response and recovery.

	CO5: Demonstrate effective communication skills through oral and written presentations of natural hazard and disaster management concepts, plans, and strategies, and engage in collaborative problem-solving with peers and professionals in the field.

Course Outline

Unit	Description
I	**Introduction:** Definition of hazard; natural, technological, and context hazards; concept of risk and vulnerability; reasons of vulnerability - rapid population growth, urban expansion, environmental pollution, epidemics, industrial accidents, inadequate government policies.
II	**Natural hazards:** Natural hazards: hydrological, atmospheric & geological hazards; earthquake: seismic waves, epicenter; volcanoes: causes of volcanism, geographic distribution; landslides: causes and types of landslides, landslide analysis; cyclones; lighting; hailstorms; floods: types and nature, frequency of flooding;; drought: types of drought - meteorological, agricultural, hydrological, and famine; Glacial Lake Outburst Floods (GLOF); tornadoes, cyclone & hurricanes; tsunamis: causes and location of tsunamis; coastal erosion, sea level changes and its impact on coastal areas and coastal zone management.
III	**Anthropogenic hazards:** Impacts of anthropogenic activities such as rapid urbanization, injudicious ground water extraction, sand mining from riverbank, deforestation, mangroves destruction; role of construction along riverbanks in elevating flood hazard; disturbing flood plains. deforestation and landslide hazards associated with it; large scale developmental projects, like dams and nuclear reactors in hazard prone zones; nature and impact of accidents, wildfires and biophysical hazards. Case studies of Bhopal, Minamata and Chernobyl disaster.
IV	**Risk and vulnerability assessment:** Two components of risk: likelihood and consequences, qualitative likelihood measurement index; categories of consequences (direct losses, indirect losses, tangible losses, and intangible losses); application of geoinformatics in hazard, risk & vulnerability assessment.
V	**Mitigation and preparedness:** Concept of mitigation; types of mitigation: structural and non-structural mitigation, use of technologies in mitigations such as barrier, deflection and retention systems; concept of preparedness; importance of planning, exercise, and training in preparedness; role of public, education and media in hazard preparedness.
VI	**Disaster management in India:** Lessons from the past considering the examples of Bhuj earthquake, tsunami disaster, and Bhopal tragedy; National Disaster Management Framework, national response mechanism, role of government bodies such as NDMC and IMD; role of armed forces and media in disaster management; role of space technology in disaster management; case studies of efficient disaster management protocols undertaken during tropical cyclones in India.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text and Reference Books:

1. Coppola D. P. 2007. Introduction to International Disaster Management. Butterworth Heinemann.
2. Cutter, S.L. 2012. Hazards Vulnerability and Environmental Justice. EarthScan, Routledge Press.
3. Keller, E. A. 1996. Introduction to Environmental Geology. Prentice Hall, Upper Saddle River, New Jersey.
4. Pine, J.C. 2009. Natural Hazards Analysis: Reducing the Impact of Disasters. CRC Press, Taylor and Francis Group.
5. Schneid, T.D. & Collins, L. 2001. Disaster Management and Preparedness. Lewis Publishers, New York, NY.
6. Smith, K. 2001. Environmental Hazards: Assessing Risk and Reducing Disaster. Routledge Press.
7. Wallace, J.M. & Hobbs, P.V. 1977. Atmospheric Science: An Introductory Survey. Academic Press, New York.
8. Wasson, R.J., Sundriyal, Y.P., Chaudhary, S., Jaiswal, M.K., Morthekai, P., Sati, S.P.&Juyal, N. 2013. A 1000-year history of large floods in the upper Ganga catchment, central Himalaya, India. Quaternary Science Reviews 77: 156–166.

SEC A2: Human-Wildlife Conflict and Management

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	III

Course Title	SEC A2: Human-Wildlife Conflict and Management
Course Code	EVS11218
Credit	2
Contact Hours (L-T-P)	2-0-0
Course Type	Theory
Course Objective	The objectives of this course are • Understanding the causes and nature of human-wildlife conflicts, including conflicts over resources such as land, water, and food. • Examining the ecological and social impacts of human-wildlife conflicts on both wildlife and human populations. • Identifying the strategies and techniques used for mitigating human-wildlife conflicts, including those based on ecological, social, and economic factors. • Developing an understanding of the policies and regulations governing human- wildlife conflicts and their management. • Developing practical skills in designing and implementing management plans for human-wildlife conflicts in different contexts, such as urban, rural, and protected areas. • 6Analyzing the ethical, social, and cultural dimensions of human-wildlife conflicts and their management, including the roles of local communities and indigenous peoples. • Understanding the role of interdisciplinary approaches in addressing human-wildlife conflicts, including the integration of ecology, social sciences, and policy. • Analyzing the role of technology and innovation in mitigating human-wildlife conflicts, such as the use of non-lethal deterrents, remote sensing, and citizen science.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Analyse the factors and underlying causes of human-wildlife conflict and identify potential solutions for conflict resolution.

	CO2: Understand the ecological and social impacts of human-wildlife conflict on both humans and wildlife populations and identify ways to mitigate these impacts. **CO3:** Analyse and evaluate the effectiveness of different management techniques and strategies used to prevent and manage human-wildlife conflict. **CO4:** Understand the legal and policy frameworks related to human-wildlife conflict management and evaluate their effectiveness in promoting conflict resolution and sustainable wildlife management. **CO5:** Develop and implement effective communication strategies for raising public awareness about human-wildlife conflict and promoting community-based solutions for conflict resolution.

Course Outline

Unit	Description
I	**Introduction to wildlife management:** Need of environmental management; wildlife conservation: moral obligation? philosophy of wildlife management; why is it necessary to worry about human wildlife conflicts? What is the role of government, wildlife biologists and social scientists, concept of deep and shallow ecology.
II	**Evolution of the concept of wildlife management:** Journey of mankind from predator to conservator; prehistoric association between wildlife and humans: records from Bhimbetka wall paintings; conservation of wildlife in the reign of king Ashoka: excerpts from rock edicts; Bishnoi community; understanding wildlife management, conservation and policies regarding protected areas in 21st century; positive values provided by wildlife conservation (monetary, recreational, scientific and ecological benefits).
III	**Wildlife conservation laws in India:** Types of protected areas (Wildlife Sanctuaries, National Parks, Biosphere Reserves); IUCN categories of protected areas, Natural World Heritage sites; concept of core and buffer area in a protected range, brief introduction to Wildlife Protection Act of 1972, Forest act 1927, Environmental Protection Act 1986, and Forest conservation Act 1920; introduction of Tiger task force, Status of current protected areas in India.
IV	**Socio-economic and legal basis of conflicts:** Concepts of development and encroachment, who is the intruders: human or animal? Impact of conflict on humans and wildlife, impact of habitat fragmentation, social inequality in terms of forest conservation: luxury hotels within protected areas vs. displacement of native tribes, forest produce as a need vs. forest exploitation, introduction to tribal rights in India, demographic profile of tribes in India, importance of forest produce to tribal populations, Scheduled tribes and other traditional Forest dwellers (Recognition of forest right) Act, 2006.

V	**Wildlife conflicts:** Insight into the important conflicts: Keoladeo National Park conflict of Bharatpur, Human and elephant conflicts of Kerala, Fisherman and tiger conflict of Sundarbans forest, shifting cultivation in North east India.
VI	**Human wildlife coexistence:** Symbiotic relationship between tribals and forest, forest and development, focus on the inclusive growth of tribes: community participation in forest management, case study of Chipko movement, sacred groves forests, India's Bishnoi community and their conservation practices; ecological economic welfare and development: conservation of indigenous culture and traditions, role of international organizations: Man and biosphere programmes; concept of conservation reserves and community reserves, importance of wildlife corridors in minimizing the conflicts and conservation.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text and Reference Books:

1. Conover, M. 2001. Resolving Human Wildlife Conflicts, CRC Press.
2. Dickman, A. J. 2010. Complexities of conflict: the importance of considering social factors for effectively resolving human–wildlife conflict. Animal Conservation 13: 458-466.
3. Messmer, T. A. 2000. The emergence of human–wildlife conflict management: Turning challenges into opportunities. International Biodeterioration & Biodegradation 45: 97-102.
4. Paty, C. 2007. Forest Government and Tribe. Concept Publishing Company.
5. Treves, A. & Karanth, K. U. 2003. Human-- ‐ carnivore conflict and perspectives on carnivore management worldwide. Conservation Biology 17: 1491-1499.
6. Woodroffe, R. 2005. People and Wildlife: Conflict and Coexistence. Cambridge.
7. Woodroffe, R., Thirgood, S., & Rabinowitz, A. 2005. People and Wildlife, Conflict or Coexistence? (No. 9). Cambridge University Press.

Program Outcome Vs Courses Mapping Table of Semester: IV

Course Code	Course Name	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
EVS11219	Environmental Biochemistry and Biotechnology	CO1	2	2	3	3	2	1	3	1	3	3
		CO2	3	1	1	2	2	2	2	2	2	2
		CO3	3	2	2	2	3	2	2	3	2	2
		CO4	2	2	3	1	2	3	2	1	1	3
		CO5	3	3	2	3	3	1	1	3	2	2
		CO	2.6	2	2.2	2.2	2.4	1.8	2	2	2	2.4
EVS11220	Natural Resource Management and Sustainability	**COs**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PSO1**	**PSO2**	**PSO3**
		CO1	2	2	1	3	2	1	2	1	1	2
		CO2	2	3	3	-	2	3	2	-	2	-
		CO3	3	2	1	2	3	1	2	2	2	2
		CO4	2	1	2	3	2	2	2	3	3	1
		CO5	3	2	2	3	3	1	2	2	-	2
EVS11221	Systematics and Biodiversity	CO1	2	2	3	3	2	1	2	1	3	3
		CO2	2	3	1	2	2	2	1	2	2	1
		CO3	3	2	2	2	2	2	2	2	2	2
		CO4	3	3	3	3	2	2	2	2	3	3
		CO5	3	2	1	2	3	3	1	3	1	2
		CO	2.6	2.4	2	2.4	2.2	2	1.6	2	2.2	2.2

Correlation level 1, 2 and 3 as defined below:

"1" – Slight (Low)
"2" - Moderate (Medium)
"3" – Substantial (High)
"-" – No correlation

School of Basic and Applied Sciences
BSc (Hons) Environmental Science
Batch: 2022-23
Semester: IV

S. No.	Type of Course	Course Code	Course Title	Teaching Load				CREDITS
				L	**T**	**P**	**TOTAL**	
1	Core Theory	EVS11219	Environmental Biochemistry and Biotechnology	4	0	0	4	4
2	Core Theory	EVS11220	Natural Resource Management and Sustainability	4	0	0	4	4
3	Core Theory	EVS11221	Systematics and Biodiversity	4	0	0	4	4
4	GE Theory	GEO11005	GE Geography II	4	0	0	4	4
5	Core Practical	EVS12222	Environmental Biochemistry and Biotechnology Lab	0	0	3	3	2
6	Core Practical	EVS12223	Natural Resource Management and Sustainability Lab	0	0	3	3	2
7	Core Practical	EVS12224	Systematics and Biodiversity Lab	0	0	3	3	2
8	GE Practical	GEO12006	GE Geography II Lab	0	0	4	4	2
9	Value Added Course	PSG11021	Human Values and Professional Ethics	0	2	0	2	2
10	SEC Theory	EVS11225	SEC B1: Gender and Environment	2	0	0	2	2
		OR						
		EVS11226	SEC B2: Health, Safety and Environment					
			Total	**18**	**2**	**13**	**33**	**28**

Environmental Biochemistry and Biotechnology

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	IV
Course Title	Environmental Biochemistry and Biotechnology
Course Code	EVS11219
Credit	4
Contact Hours (L-T-P)	4-0-0
Course Type	Theory
Course Objective	The objectives of this course are • To introduce students to the basic principles of biochemistry and their applications in environmental biotechnology. • To provide students with a comprehensive understanding of the molecular basis of biological processes and their significance in environmental systems. • To develop students' skills in designing and conducting experiments using biochemical and biotechnological techniques to solve environmental problems. • To provide students with an understanding of the role of enzymes and microorganisms in environmental biotechnology and their potential applications in environmental remediation and waste management. • To develop students' critical thinking and problem-solving skills by analyzing case studies related to environmental biochemistry and biotechnology.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Understand the basic principles of biochemistry and biotechnology and their application in environmental sciences.

	CO2: Analyse and evaluate environmental samples using modern biochemical and biotechnological techniques. **CO3:** Understand the role of microorganisms in environmental processes and bioremediation of pollutants. **CO4:** Evaluate the potential applications of biotechnology in environmental management and sustainability. **CO5:** Understand the ethical considerations related to the use of biotechnology in environmental applications.

Course Outline

Unit	Description
I	**Biomolecules: Monosaccharides:** Aldoses and ketoses, structure of D- glucose & D-fructose (configuration & conformation), anomeric effect, mutarotation. nature of glycosidic linkages; structure and systematic names of sucrose, lactose, maltose, Amino acids: Synthesis: (Strecker, Gabriel, acetamidomalonic ester, azlactone); isoelectric point, ninhydrin reaction. Peptides: peptide linkage, synthesis of peptides using N-protection & C-protection, solid phase synthesis; peptide sequence: C-terminal and N-terminal amino acid determination (Edman, Sanger & dansyl chloride). Primary, secondary, tertiary and quaternary structure of proteins and protein folding. Nucleic acids: pyrimidine & purine bases (only structure & nomenclature), nucleosides and nucleotides, DNA: Watson-Crick model, DNA: structural forms and their characteristics (B, A, C, D, T, Z); physical properties: UV absorption spectra, denaturation and renaturation kinetics; biological significance of different forms; Synthesis. RNA: structural forms and their characteristics (rRNA, mRNA, tRNA; SnRNA, Si RNA, miRNA, hnRNA); biological significance of different types of RNA; synthesis.; Fatty acids- properties of saturated and unsaturated fatty acids. Esters of fatty acids-formation and hydrolysis; Essential fatty acids. Triacylglycerols. Reactions and characterization of fats biological significance of fats. Cofactors – Definition, examples of a) metal ions b) coenzymes c) prosthetic group; Definition, examples of holoenzymes, Apoenzyme. Classification of enzymes, IUPAC system, Name & examples of each class Mechanism of enzyme activity Concept of Central Dogma.
II	**Few important biochemical pathways and cycles:** Bioenergetics and Metabolism: Principles of Bioenergetics: Bioenergetics and Thermodynamics, Phosphoryl group transfers and ATP generation, Biological Oxidation and Reduction reaction. Intracellular metabolism of glucose - glycolysis, reaction and energetic of TCA cycle, (gluconeogenesis, glycogenesis, glycogenolysis, reactions and physiological significance of pentose phosphate pathway, regulation of glycolysis, TCA cycle, and glycogen metabolism).
III	**Ecological restoration and bioremediation:** Wastewater treatment: anaerobic, aerobic process, methanogenesis, bioreactors, cell and protein (enzyme) immobilization techniques; treatment schemes for wastewater: dairy, distillery, tannery, sugar, antibiotic industries; solid waste treatment: sources and management (composting, vermiculture and methane production, landfill. hazardous waste treatment); specific

	bioremediation technologies: land farming, prepared beds, biopiles, composting, bioventing, biosparging, pump and treat method, constructed wetlands, use of bioreactors for bioremediation; phytoremediation; remediation of degraded ecosystems; advantages and disadvantages; degradation of xenobiotics in environment, decay behavior and degradative plasmids, hydrocarbons, substituted hydrocarbons, oil pollution, surfactants, pesticides, heavy metals degradative pathways.
IV	**Ecologically safe products and processes:** PGPR bacteria: biofertilizers, microbial insecticides and pesticides, bio-control of plant pathogen, Integrated pest management; development of stress tolerant plants, biofuel; mining and metal biotechnology: microbial transformation, accumulation and concentration of metals, metal leaching, extraction; exploitation of microbes in copper and uranium extraction. Basic concept of bio-patenting.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text and Reference Books:

1. Evans, G.G. & Furlong, J. 2010. Environmental Biotechnology: Theory and Application (2 nd edition). Wiley Blackwell Publications.
2. Jordening, H.J. & Winter J. 2005. Environmental Biotechnology: Concepts and Applications. John Wiley & Sons.
3. Lodish, H.F., Baltimore, D., Berk, A. Zipursky, S.L. Matsudiara, P. & Darnell, J. 1995. Molecular Cell Biology. W.H. Freeman.
4. Nelson, D.L. & Cox, M.M. 2013. Lehninger's Principles of Biochemistry. W.H. Freeman.
5. Rittman, B.E. & McCarty, P.L. 2001. Environmental Biotechnology. Principles and Applications. McGraw-Hill, New York.
6. Scagg, A.H. 2005. Environmental Biotechnology. Oxford University Press. Snustad, D.P. & Simmons, M.J. 2011. Principles of Genetics (6th edition). John Wiley & Sons.
7. Wainwright, M. 1999. An Introduction to Environmental Biotechnology. Springer.

Natural Resource Management and Sustainability

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	IV
Course Title	Natural Resource Management and Sustainability
Course Code	EVS11220
Credit	4
Contact Hours (L-T-P)	4-0-0
Course Type	Theory
Course Objective	The objectives of this course are • To introduce students to the principles and practices of sustainable natural resource management, with a focus on conservation and preservation of natural resources for present and future generations. • To provide students with an understanding of the ecological, economic, and social factors that influence natural resource management decisions and policies. • To teach students about the current and emerging issues in natural resource management and their impact on sustainability, such as climate change, biodiversity loss, and resource depletion. • To help students develop skills in analyzing natural resource management problems, designing solutions, and implementing strategies to promote sustainability. • To encourage students to think critically and creatively about natural resource management challenges, and to engage in interdisciplinary and collaborative approaches to finding solutions.

	• To foster an appreciation of the ethical and cultural dimensions of natural resource management, and to develop a sense of responsibility and stewardship towards natural resources and the environment.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Understand the principles of natural resource management and sustainability, including the concept of carrying capacity, conservation, and sustainable use. **CO2:** Analyse the impacts of human activities on natural resources and ecosystems, including land use, pollution, climate change, and biodiversity loss. **CO3:** Evaluate the effectiveness of natural resource management policies and strategies, including the use of economic incentives, regulations, and community-based approaches. **CO4:** Develop skills in data collection, analysis, and interpretation related to natural resource management, including GIS, remote sensing, and statistical methods**.** **CO5:** Apply interdisciplinary approaches to natural resource management and sustainability, including understanding the social, economic, and political contexts that influence resource use and management.

Course Outline

Unit	Description
I	**Introduction:** Resource and reserves; classification of natural resources; renewable and non-renewable resources; resource degradation; resource conservation; resource availability and factors influencing its availability; land resources; water resources; fisheries and other marine resources; energy resources; mineral resources; human impact on natural resources; ecological, social and economic dimension of resource management.
II	**Natural resources and conservation:** Forest resources: economic and ecological importance of forests, forest management strategies, sustainable forestry; water resources: supply, renewal, and use of water resources, freshwater shortages, strategies of water conservation; soil resources: importance of soil, soil conservation strategies; food resources: world food problem, techniques to increase world food production, green revolution.
III	**Mineral resources:** Mineral resources and the rock cycle; identified resources; undiscovered resources; reserves; types of mining: surface, subsurface, open-pit, dredging, strip; reserve-to-production ratio; global consumption patterns of mineral resources techniques to increase mineral resource supplies; ocean mining for mineral resources; environmental effects of extracting and using mineral resources.

IV	**Energy resources**: Non-renewable energy resources: Oil: formation, exploration, extraction and processing, oil shale, tar sands; natural gas: exploration, liquefied petroleum gas, liquefied natural gas; coal: reserves, classification, formation, extraction, processing, coal gasification; environmental impacts of non-renewable energy consumption; impact of energy consumption on global economy; application of green technology; future energy options and challenges. Renewable energy resources: Energy efficiency; life cycle cost; cogeneration; solar energy: technology, advantages, passive and active solar heating system, solar thermal systems, solar cells, JNN solar mission; hydropower: technology, potential, operational costs, benefits of hydropower development; nuclear power: nuclear fission, fusion, reactors, pros and cons of nuclear power, storage of radioactive waste, radioactive contamination; tidal energy; wave energy; ocean thermal energy conversion (OTEC); geothermal energy; energy from biomass; bio-diesel.
V	**Resource management:** Approaches in resource management: ecological approach; economic approach; ethnological approach; implications of the approaches; integrated resource management strategies; concept of sustainability science: different approach towards sustainable development and its different constituents; sustainability of society, resources, and framework; sustainable energy strategy; principles of energy conservation; Indian renewable energy programme.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text and Reference Books:

1. Craig, J.R., Vaughan. D.J. & Skinner. B.J. 1996. Resources of the Earth: Origin, Use, and Environmental Impacts (2nd edition). Prentice Hall, New Jersey.
2. Freeman, A.M. 2001. Measures of value and Resources: Resources for the Future.Washington DC.
3. Freeman, A.M. 2003. Millennium Ecosystem Assessment: Conceptual Framework. Island Press.
4. Ginley, D.S. & Cahen, D. 2011. Fundamentals of Materials for Energy and Environmental Sustainability. Cambridge University Press.

5. Klee, G.A. 1991. Conservation of Natural Resources. Prentice Hall Publication.
6. Miller, T.G. 2012. Environmental Science. Wadsworth Publishing Co.
7. Owen, O.S, Chiras, D.D, & Reganold, J.P. 1998. Natural Resource Conservation Management for Sustainable Future (7th edition). Prentice Hall.
8. Ramade, F. 1984. Ecology of Natural Resources. John Wiley & Sons Ltd.
9. Tiwari, G.N. & Ghosal. M. K. 2005. Renewable Energy Resources: Basic Principles and Application. Narosa Publishing House.

Systematics and Biodiversity

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	IV
Course Title	Systematics and Biodiversity
Course Code	EVS11221
Credit	4
Contact Hours (L-T-P)	4-0-0
Course Type	Theory
Course Objective	The objectives of this course are • Understand the fundamental principles of systematics, including the process of biological classification, and the key concepts of taxonomy, phylogeny, and evolutionary relationships. • Develop the skills needed to identify, describe, and classify different groups of organisms, including their physical characteristics, ecological roles, and geographic distribution. • Analyse the diversity of life on Earth, including the patterns of species richness, the factors that drive

	biodiversity, and the threats to global biodiversity, such as habitat destruction and climate change. • Evaluate the importance of biodiversity for human well-being, including ecosystem services, cultural values, and the potential for bioprospecting and biotechnology. • Apply knowledge of systematics and biodiversity to real-world problems, such as conservation planning, restoration ecology, and sustainable resource management, and develop critical thinking skills to evaluate and address complex biological challenges.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Understand the history and principles of systematics, including the development of classification systems and the role of evolutionary theory in understanding biodiversity. **CO2:** Understand the history and principles of systematics, including the development of classification systems and the role of evolutionary theory in understanding biodiversity. **CO3:** Develop skills in the identification, description, and classification of different groups of organisms, including the use of traditional and molecular approaches. **CO4:** Evaluate the importance of biodiversity for human well-being, including ecosystem services, cultural values, and the potential for bioprospecting and biotechnology. **CO5:** Apply knowledge of systematics and biodiversity to real-world problems, such as conservation planning, restoration ecology, and sustainable resource management, and develop critical thinking skills to evaluate and address complex biological challenges.

Course Outline

Unit	Description
I	**Concept of Taxonomic hierarchy and Nomenclature:** Definition of systematics; taxonomic identification; keys; taxonomic literature; nomenclature; Concept of taxa (species, genus, family, order, class, phylum, kingdom); concept of species (taxonomic, typological, biological, evolutionary, phylogenetic); taxonomic hierarchy, taxonomy databases, International Code of Botanical and Zoological Nomenclature; ranks and names; types and typification; principle classification schemes of Bentham and Hooker; Characters; variations; phenograms; cladograms; DNA barcoding; phylogenetic tree (rooted, unrooted, ultrametric trees); clades: monophyly, paraphyly, polyphyly; homology and analogy; parallelism and convergence.

II	**From genes to ecosystems:** Tree of life; history of character transformation; organic evolution through geographic time scale; species concept – what's in a name?; how many species are there on earth?; concept and types of speciation. Spatial patterns: latitudinal and elevational trends in biodiversity; temporal patterns: seasonal fluctuations in biodiversity patterns; importance of biodiversity patterns in conservation. Sampling strategies and surveys: floristic, faunal, and aquatic; qualitative and quantitative methods: scoring, habitat assessment, richness, density, frequency, abundance, evenness, diversity, biomass estimation; community diversity estimation: alpha, beta and gamma diversity; molecular techniques: RAPD, RFLP, AFLP; NCBI database, BLAST analyses.
III	**Importance of biodiversity:** Economic values – medicinal plants, drugs, fisheries and livelihoods; ecological services – primary productivity, role in hydrological cycle, biogeochemical cycling; ecosystem services – purification of water and air, nutrient cycling, climate control, pest control, pollination, and formation and protection of soil; social, aesthetic, consumptive, and ethical values of biodiversity.
IV	**Conservation Biogeography:** Natural and anthropogenic disturbances; habitat loss, habitat degradation, and habitat fragmentation; climate change; pollution; hunting; over-exploitation; land use changes; overgrazing; invasive species; man-wildlife conflicts; consequences of biodiversity loss. In-situ and Ex-situ conservation, role of local communities and traditional knowledge in conservation; biodiversity hotspots; IUCN Red List categorization – guidelines, practice and application; Red Data book; ecological restoration: social forestry; agro forestry; joint forest management; role of remote sensing in management of natural resources. Application of biogeographical rules in design of protected area and biosphere reserves; use of remote sensing in conservational planning. India as a mega-diversity nation; phytogeographic and zoogeographic zones of the country, National Biodiversity Action Plan.
V	**Biological invasions:** Concept of exotics and invasives; natural spread versus man-induced invasions; characteristics of invaders; stages of invasion; mechanisms of invasions; invasive pathways; impacts of invasion on ecosystem and communities; invasive ecogenomics – role of polyploidy and genome size in determining invasiveness; economic costs of biological invasions.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text and Reference Books:

1. Lomolino, M.V., Riddle, B.R., Whittaker, R.J. & Brown, J.H. 2010. Biogeography (4th edition). Sinauer Associates, Sunderland.
2. Mani, M.S. 1974. Ecology and Biogeography in India. Dr. W Junk Publishers., The Hague.
3. Singh, G. 2012. Plant Systematics: Theory and Practice (3rd edition). Oxford & IBH Pvt Ltd., New Delhi.
4. Williams, D. M. & Ebach, M.C. 2008. Foundations of Systematics and Biogeography.Springer.
5. Wilkins, J. S. 2009. Species: A History of the Idea (Vol. 1). University of California Press.
6. Gaston, K J. & Spicer, J.I. 1998. Biodiversity: An Introduction. Blackwell Science, London, UK.
7. Krishnamurthy, K.V. 2004. An Advanced Text Book of Biodiversity - Principles and Practices. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi.
8. Primack, R.B. 2002. Essentials of Conservation Biology (3rd edition). Sinauer Associates, Sunderland, USA.
9. Singh, J. S. & Singh, S. P. 1987. Forest vegetation of the Himalaya. The Botanical Review 53: 80-192.
10. Singh, J. S., Singh, S.P. & Gupta, S. 2006. Ecology, Environment and Resource Conservation. Anamaya Publications, New Delhi.
11. Sodhi, N.S. & Ehrlich, P.R. (Eds). 2010. Conservation Biology for All. Oxford University Press.

Environmental Biochemistry and Biotechnology Lab

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	IV
Course Title	Environmental Biochemistry and Biotechnology Lab
Course Code	EVS12222

Credit	2
Contact Hours (L-T-P)	0-0-3
Course Type	Practical
Course Objective	The objectives of this course are • To develop practical laboratory skills in biochemistry and biotechnology techniques relevant to the environmental sciences, including protein isolation, enzyme assays, DNA extraction, PCR, and electrophoresis. • To apply these laboratory techniques to study the metabolic processes of microorganisms in the environment, including the use of microbiological methods to characterize microbial communities, measure microbial activity, and assess bioremediation potential. • To understand the molecular mechanisms of bioremediation and the use of biotechnology to address environmental challenges such as pollution, waste management, and climate change. • To evaluate the environmental impact of biotechnological processes, including assessing the potential for ecological and health risks, and the ethical considerations of using biotechnology in environmental management. • To develop critical thinking and problem-solving skills by designing, conducting, and analyzing experiments related to environmental biochemistry and biotechnology, and communicating scientific results through written reports and oral presentations.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Develop practical laboratory skills in biochemistry and biotechnology techniques relevant to environmental sciences, including protein isolation, enzyme assays, DNA extraction, PCR, and electrophoresis. **CO2:** Apply laboratory techniques to study the metabolic processes of microorganisms in the environment, including the use of microbiological methods to characterize microbial communities, measure microbial activity, and assess bioremediation potential. **CO3:** Understand the molecular mechanisms of bioremediation and the use of biotechnology to address environmental

	challenges such as pollution, waste management, and climate change. **CO4:** Evaluate the environmental impact of biotechnological processes, including assessing the potential for ecological and health risks, and the ethical considerations of using biotechnology in environmental management. **CO5:** Develop critical thinking and problem-solving skills by designing, conducting, and analyzing experiments related to environmental biochemistry and biotechnology, and communicating scientific results through written reports and oral presentations.

Course Outline

Unit	Description
I	1. Isolation and characterisation of soil bacteria. 2. Gram staining of bacterial sample. 3. Enumeration of heterotrophic bacteria from water and soil samples (Spread plate/pore plate technique). 4. Determination of chlorophylls, enzymes (catalase, peroxidase and ascorbic acid of plant samples). 5. Bioassay of toxic compounds by enzyme assay or seed germination test. 6. Estimation of carbohydrate, protein and DNA. 7. Study of mitotic and meotic stages (A. cepa and grasshopper testis or pollen). 8. Gram Staining, Total coliform count (MPN), ABO Blood grouping. 9. Qualitative tests for carbohydrates, proteins and lipids 10. Qualitative estimation of Urea & Uric acid 11. Paper chromatography of amino acids. 12. Quantitative estimation of water-soluble proteins following Lowry Method 13. Gram Staining 14. Total coliform count (MPN) 15. Packing and sterilization of glass and plastic wares for cell culture. 16. Preparation of culture media. 17. Preparation of genomic DNA from E. coli/animals/ human.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Natural Resource Management and Sustainability Lab

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	IV
Course Title	Natural Resource Management and Sustainability Lab
Course Code	EVS12223
Credit	2
Contact Hours (L-T-P)	0-0-3
Course Type	Practical
Course Objective	The objectives of this course are • To develop practical laboratory skills in field sampling and data collection techniques relevant to natural resource management and sustainability, including water quality testing, soil analysis, and biodiversity assessments. • To apply these laboratory techniques to study the ecological processes and environmental impacts of human activities on natural resources, including identifying and assessing the impacts of pollution, habitat destruction, and climate change. • To understand the principles of sustainable resource management, including ecosystem-based management, adaptive management, and conservation biology. • To evaluate the effectiveness of natural resource management strategies, including assessing the social, economic, and ecological implications of different management approaches. • To develop critical thinking and problem-solving skills by designing, conducting, and analyzing experiments related to natural resource management and

	sustainability, and communicating scientific results through written reports and oral presentations.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Develop practical laboratory skills in field sampling and data collection techniques relevant to natural resource management and sustainability, including water quality testing, soil analysis, and biodiversity assessments. **CO2:** Apply laboratory techniques to study the ecological processes and environmental impacts of human activities on natural resources, including identifying and assessing the impacts of pollution, habitat destruction, and climate change. **CO3:** Understand the principles of sustainable resource management, including ecosystem-based management, adaptive management, and conservation biology. **CO4:** Evaluate the effectiveness of natural resource management strategies, including assessing the social, economic, and ecological implications of different management approaches. **CO5:** Develop critical thinking and problem-solving skills by designing, conducting, and analyzing experiments related to natural resource management and sustainability, and communicating scientific results through written reports and oral presentations.

Course Outline

Unit	Description
I	1. Forest area mapping techniques. 2. Water bodies mapping techniques. 3. Water audit of college/ industry. 4. Energy audit of college/ industry. 5. Environmental audit of college. 6. Visit to mine area, forest area and aquaculture farm.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Systematics and Biodiversity Lab

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	IV
Course Title	Systematics and Biodiversity Lab
Course Code	EVS12224
Credit	2
Contact Hours (L-T-P)	0-0-3
Course Type	Practical
Course Objective	The objectives of this course are • To develop practical laboratory skills in the collection and preservation of specimens for systematic study, including methods for preparing and labeling specimens, and data collection and management. • To apply techniques for morphological, molecular, and ecological analysis of biodiversity, including the use of microscopy, DNA sequencing, and field surveys. • To understand the principles of systematics and taxonomy, including the classification and naming of organisms, and the use of phylogenetic analysis to study evolutionary relationships. • To use scientific methods to identify and describe species, and to develop skills in species delimitation and phylogenetic inference. • To communicate scientific results through written reports and oral presentations, and to develop skills in scientific writing and data visualization.
Course Outcome (CO)	After completion of this course, students will be able to:

	CO1: Develop practical laboratory skills in the collection and preservation of specimens for systematic study, including methods for preparing and labeling specimens, and data collection and management. **CO2:** Apply techniques for morphological, molecular, and ecological analysis of biodiversity, including the use of microscopy, DNA sequencing, and field surveys. **CO3:** Understand the principles of systematics and taxonomy, including the classification and naming of organisms, and the use of phylogenetic analysis to study evolutionary relationships. **CO4:** Use scientific methods to identify and describe species, and develop skills in species delimitation and phylogenetic inference. **CO5:** Communicate scientific results through written reports and oral presentations, and develop skills in scientific writing and data visualization.

Course Outline

Unit	Description
I	1. Identification of suitable flora and fauna (Definite list of specimens of ecological and economic significance). 2. Identification Key Preparation. 3. Assessments of Biodiversity (Frequency, density, abundance, relative density) 4. Biodiversity indices (Shannon wiener diversity index, Simpson's index, Simpson's index of diversity, evenness index) 5. Laboratory Note book and Viva Voce.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

SEC B1: Gender and Environment

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	IV
Course Title	SEC B1: Gender and Environment
Course Code	EVS11225
Credit	2
Contact Hours (L-T-P)	2-0-0
Course Type	Theory
Course Objective	The objectives of this course are • To understand the complex and interconnected relationships between gender and the environment, and how they intersect with other social identities and structures of power. • To critically Analyse the impacts of environmental degradation and climate change on different genders and communities, particularly those who are most vulnerable and marginalized. • To explore gendered experiences of environmental activism, conservation, and sustainable development, and to examine the roles and contributions of women and non-binary individuals in these areas. • To develop skills in gender-sensitive research and policy analysis related to the environment, including the ability to identify and address gender biases and inequalities in existing research and policy frameworks. • To communicate effectively and respectfully about issues related to gender and the environment, and to develop strategies for engaging diverse stakeholders in dialogue and action for environmental justice.

Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Demonstrate an understanding of key concepts related to gender, intersectionality, and environmental justice, and their intersections with environmental issues. **CO2:** Analyse the impacts of environmental degradation and climate change on different genders and communities, and critically evaluate existing research and policy frameworks through a gender-sensitive lens. **CO3:** Examine gendered experiences of environmental activism, conservation, and sustainable development, and evaluate the roles and contributions of women and non-binary individuals in these areas. **CO4:** Develop research and analytical skills in gender-sensitive research and policy analysis related to the environment, including the ability to identify and address gender biases and inequalities in existing research and policy frameworks. **CO5:** Communicate effectively and respectfully about issues related to gender and the environment, and develop strategies for engaging diverse stakeholders in dialogue and action for environmental justice.

Course Outline

Unit	Description
I	**Introduction:** The socially constructed 'gender' concept.
II	**Gender and society:** Gender existence in society; gender: matriarchy and patriarchy as means of social exclusion (case studies in an Indian context); gender equity issues in rural and urban settings.
III	**Gender and the environment:** Relevance of the concept in an environmental context; evolution of gender hierarchies in historical and contemporary perspective; gendered division of roles in cultural, social and economic perspective; gender inequalities.
IV	**Gender, resources and the environment:** Knowledge about the environment among men and women; differential dependencies on environmental resources; implications of gendered responses to environmental degradation.
V	**Gender and environmental management:** Women's participation in environmental movements and conservation; historical and contemporary case studies; role of women in environmental education, awareness and sustainable development.
VI	**Strategies for change:** Need for gender equity; Instruments for change: education, media, action groups, policy and management; equity in resource availability and consumption for a sustainable future.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text and Reference Books:

1. Agarwal, B. 1992. The Gender and Environment Debate: Lessons from India. Feminist Studies (Minnesota).
2. Agarwal, B. 1997. Gender, Environment and Poverty Interlinks: Regional Variations and Temporal Shifts in Rural India: 1971-1991. World Development 25: 1-42.
3. Agarwal, B. 2001. Participatory exclusions, community forestry, and gender: An analysis for South Asia and a conceptual framework. World Development 29: 1623-1648.
4. Jackson, C. 1993. Doing what comes naturally? Women and environment in development World Development 21: 1947-63.
5. Krishna, S. 2004. Livelihood and Gender. New Delhi, Sage.
6. Leach, M. 2007. Earth Mother myths and other ecofeminist fables: How a strategic notion rose and fell. Development and Change 38: 67-85.
7. Miller, B. 1993. Sex and Gender Hierarchies. Cambridge University Press.
8. Stein, R. (ed.). 2004. New Perspectives on Environmental Justice: Gender, Sexuality, and Activism. Rutgers University Press.
9. Steingraber, S. 1998. Living Downstream: A Scientist's Personal Investigation of Cancer and the Environment. New York: Vintage Books.
10. Zwarteveen, M.Z. 1995. Linking women to the main canal: Gender and irrigation management. Gatekeeper Series 54, IIED.

SEC B2: Health, Safety and Environment

School	School of Basi and Applied Science
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	IV
Course Title	SEC B2: Health, Safety and Environment
Course Code	EVS11226
Credit	2
Contact Hours (L-T-P)	2-0-0
Course Type	Theory
Course Objective	The objectives of this course are • To understand the fundamental principles of occupational health and safety, and the role of employers and employees in maintaining a safe and healthy workplace. • To identify and assess hazards and risks in the workplace, and to develop strategies for preventing or mitigating those risks through hazard control and risk management. • To understand the basic principles of environmental health and safety, and to identify and assess potential environmental hazards and risks in the workplace and community. • To develop skills in incident investigation and analysis, including the ability to identify root causes of accidents and near-misses and to develop strategies for preventing future incidents. • To understand the basic principles of emergency preparedness and response, and to develop plans and procedures for responding to emergencies in the workplace and community.

Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Demonstrate knowledge of fundamental concepts and principles of occupational and environmental health and safety, including hazard identification and assessment, risk management, and regulatory frameworks and standards. **CO2:** Apply critical thinking and problem-solving skills to identify and evaluate health and safety risks and hazards in workplaces and communities and develop strategies for controlling or mitigating these risks. **CO3:** Develop skills in incident investigation, emergency preparedness and response, and regulatory compliance, and apply these skills in a range of workplace and community contexts. **CO4:** Analyse the complex relationships between health, safety, and the environment, and evaluate the social, economic, and ethical implications of health and safety decisions and policies. **CO5:** Communicate effectively and respectfully with a range of stakeholders, including employers, employees, regulatory bodies, and community members, about health, safety, and environmental issues and risks.

Course Outline

Unit	Description
I	**Physical and Chemical Hazards:** Recognition, Evaluation and Control of Physical Hazards. Noise and Vibration: Effects and Control Measures, Thermal Stress, Parameter Control. Radiation: Types, Source: Effect and Control Illumination & Lighting. Recognition, Evaluation and Control of Chemical Hazards- Types - Dust-Fumes -Mist - Vapor-Fog etc., Air Contaminants- Evaluation - Types of Sampling-Air Sampling System-Method Analysis-Control Measures.
II	**Occupational Health: Evaluation of injuries:** Medical services in industrial establishment, its function, action programs for work related diseases at the national level. Personal Protective Equipment: Introduction, requirements and assessment of PPE, types of PPE. Non-respiratory personal protective devices; head, ear, face and eye protection, feet and body protection, supply, use, care and maintenance of PPE, requirements under factory Acts and Rules. Respiratory PPE: Types of respiratory PPE, supply, use, care and maintenance of breathing apparatus, training for the use of breathing apparatus. Concept and Spectrum of Health-Functional Units and Activities of Occupational Health Services Occupational and Work-Related Disease- Levels of Prevention of Diseases - Notifiable Occupational Diseases such as Silicosis- Asbestosis- Pneumoconiosis-- Aluminosis and Anthrax. Lead-Nickel, Chromium and Manganese Toxicity-Gas Poisoning (such as CO, Ammonia, Coal Dust etc.,) their effects and Prevention- Cardiopulmonary Resuscitation- Audiology-Hearing Conservation Programme- Effects of Ultraviolet Radiation and

	Infrared Radiation on Human Systems Industrial Toxicology-Local and Systemic and Chronic Effects Temporary and Cumulative Effects Carcinogens Entry into Human System Ergonomics, Personnel Protective Equipment, Personnel Monitoring.
III	**Personal Hygiene and First Aid:** Hygiene Concepts: Correct and Clean Dresses, Clean Body, Washing, Good Habits, Oral and Stomach Hygiene: Cleaning, Compressed Air and Degreasing Agents, Long Hair and Nails and Torn and loosely Hanging Clothes, Smoking, Lavatories Maintenance, Living in Unhygienic Areas. First aid concept: First Aid Boxes, Legal Requirements, Industrial Hygiene, Medical Surveillance, Medical Surveillance Program Development, Recommended Medical Program, Emergency Treatment, Non-Emergency Treatment, Exposures to Hazardous Materials.
IV	**Protection from radiation: Radiation Control:** Radiation Shielding, Radiation Dose, Dose Measurements, Units of Exposure, Exposure Limits, Barriers for Control of Radioactivity Release, Control of Radiation Exposure to Plant Personnel, Health Physics Surveillance - Waste Management and Disposal Practices – Environmental, Releases.
V	**Safety audit:** Definition of accidents: injury, types of accidents, causes and remedial measures, injury records, prevention, modes of prevention, physiological factors, Environmental Safety: Safety awareness, annual toll of industrial accidents in India, need for safety, legal, humanitarian factors impending safety, safety audit and steps to an effective safety audit.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text and Reference Books:

1. Occupational Health and Safety Management: A Practical Approach, Third Edition, by Charles D. Reese.
2. Environmental Health and Safety Audits, Second Edition, by Lawrence B. Cahill.
3. Principles of Environmental Health and Safety Management, Second Edition, by Richard E. Fairfax.
4. Introduction to Environmental Health, Second Edition, by Jerome Nriagu.
5. Environmental Health and Safety for Hazardous Waste Sites, Second Edition, by Michael D. LaGrega.

6. Emergency Planning and Response for Libraries, Archives, and Cultural Institutions, by Johanna Wellheiser.
7. Hazardous Materials: Managing the Incident, Fourth Edition, by Christopher Hawley.
8. Fundamentals of Occupational Safety and Health, Sixth Edition, by Mark Friend and James Kohn.
9. Chemical Process Safety: Fundamentals with Applications, Third Edition, by Daniel A. Crowl and Joseph F. Louvar.

   Industrial Hygiene Reference and Study Guide, Fourth Edition, by Marilyn E. Fingerhut and David M. Valiante.

Program Outcome Vs Courses Mapping Table of Semester: V

Course Code	Course Name	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
EVS11227	Environmental Pollution and Human health	CO1	2	2	3	3	2	1	3	1	3	3
		CO2	3	1	1	2	2	2	2	2	2	2
		CO3	3	2	2	2	3	2	2	3	2	2
		CO4	2	2	3	1	2	3	2	1	1	3
		CO5	3	3	2	3	3	1	1	3	2	2
		CO	2.6	2	2.2	2.2	2.4	1.8	2	2	2	2.4
EVS11228	Analytical methods, Instrumentation and Measurement	**COs**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PSO1**	**PSO2**	**PSO3**
		CO1	2	2	1	3	2	1	2	1	1	2
		CO2	2	3	3	-	2	3	2	-	2	-
		CO3	3	2	1	2	3	1	2	2	2	2
		CO4	2	1	2	3	2	2	2	3	3	1
		CO5	3	2	2	3	3	1	2	2	-	2
EVS11229	Environmental Economics and Statistics	CO1	2	2	3	3	2	1	2	1	3	3
		CO2	2	3	1	2	2	2	1	2	2	1
		CO3	3	2	2	2	2	2	2	2	2	2
		CO4	3	3	3	3	2	2	2	2	3	3
		CO5	3	2	1	2	3	3	1	3	1	2
		CO	2.6	2.4	2	2.4	2.2	2	1.6	2	2.2	2.2
EVS11230	Solid Waste management	CO1	2	2	3	3	2	1	2	1	3	3
		CO2	2	3	1	2	2	2	1	2	2	1
		CO3	3	2	2	2	2	2	2	2	2	2
		CO4	3	3	3	3	2	2	2	2	3	3
		CO5	3	2	1	2	3	3	1	3	1	2
		CO	2.6	2.4	2	2.4	2.2	2	1.6	2	2.2	2.2
EVS11231	Green Technologies	CO1	2	2	3	3	2	1	2	1	3	3
		CO2	2	3	1	2	2	2	1	2	2	1
		CO3	3	2	2	2	2	2	2	2	2	2
		CO4	3	3	3	3	2	2	2	2	3	3
		CO5	3	2	1	2	3	3	1	3	1	2
		CO	2.6	2.4	2	2.4	2.2	2	1.6	2	2.2	2.2

EVS11232	Urban Ecosystem	CO1	2	2	3	3	2	1	3	1	3	3
		CO2	3	1	1	2	2	2	2	2	2	1
		CO3	3	1	2	2	1	2	2	3	2	2
		CO4	2	1	1	3	2	3	2	1	1	1
		CO5	3	3	2	3	3	1	1	3	2	2
		CO	2.6	1.6	1.8	2.6	2	1.8	2	2	2	1.8

Correlation level 1, 2 and 3 as defined below:

"1" – Slight (Low)
"2" - Moderate (Medium)
"3" – Substantial (High)
"-" – No correlation

School of Basic and Applied Sciences
BSc (Hons) Environmental Science
Batch: 2022-23
Semester: V

S. No.	Type of Course	Course Code	Course Title	Teaching Load				CREDITS
				L	**T**	**P**	**TOTAL**	
1	Core Theory	EVS11227	Environmental Pollution and Human health	4	0	0	4	4
2	Core Theory	EVS11228	Analytical methods, Instrumentation and Measurement	4	0	0	4	4
3	DSE I Theory	EVS11229	Environmental Economics and Statistics	4	0	0	4	4
		OR						
		EVS11230	Solid Waste management					
4	DSE II Theory	EVS11231	Green Technologies	4	0	0	4	4
		OR						
		EVS11232	Urban Ecosystem					
	Core Practical	EVS12233	Environmental Pollution and Human health Lab	0	0	3	3	2
5	Core Practical	EVS12234	Analytical methods, instrumentation, and Measurement Lab	0	0	3	3	2
6	Core Practical	EVS12235	Waste Management Site Visit	-	-	-	3	2
7	Core Practical	EVS14236	Summer Internship / Environmental camp	-	-	-	3	2
8	DSE I Practical	EVS12237	Environmental Economics and Statistics	0	0	3	3	2
		OR						
		EVS12238	Solid Waste Management					
9	DSE II Practical	EVS12239	Green Technologies Lab	0	0	3	3	2
		OR						
		EVS12240	Urban Ecosystem					
			Total	**16**	**0**	**12**	**34**	**28**

Environmental Pollution and Human Health

School	School of Basic and Applied Science
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	V
Course Title	Environmental Pollution and Human Health
Course Code	EVS11227
Credit	4
Contact Hours (L-T-P)	4-0-0
Course Type	Theory
Course Objective	The objectives of this course are • To introduce students to the basic concepts and principles of environmental pollution and its effects on human health. • To provide an overview of the major sources of environmental pollution, including air, water, soil, and food, and the pollutants associated with each source. • To examine the various pathways by which pollutants enter the human body, including inhalation, ingestion, and dermal absorption, and the mechanisms by which they cause harm. • To explore the health effects associated with exposure to common environmental pollutants, such as lead, mercury, pesticides, and air pollutants like particulate matter and ozone. • To investigate the ways in which environmental pollution impacts vulnerable populations, including children, the elderly, low-income communities, and those with pre-existing health conditions. • To evaluate strategies for preventing and mitigating the health effects of environmental pollution, including regulatory approaches, technological solutions,

	and community-based interventions. • To develop critical thinking and problem-solving skills through case studies and group projects that require students to apply course concepts to real-world environmental health challenges. • To foster effective communication skills through written and oral presentations, with an emphasis on communicating complex environmental health information to a range of stakeholders.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Describe the major sources and types of environmental pollutants, and their impact on human health. **CO2:** Explain the pathways by which pollutants enter the human body, and the mechanisms by which they cause harm. **CO3:** Analyse the health effects associated with exposure to common environmental pollutants and evaluate the risk of adverse health outcomes associated with exposure to these pollutants. **CO4:** Assess the impact of environmental pollution on vulnerable populations and propose strategies for addressing environmental health disparities. **CO5:** Evaluate regulatory approaches and technological solutions for preventing and mitigating the health effects of environmental pollution, and propose community- based interventions to address environmental health challenges.

Course Outline

Unit	Description
I	**Introduction:** Definition of pollution; pollutants; classification of pollutants.
II	**Air pollution:** Ambient air quality: monitoring and standards (National Ambient Air Quality Standards of India); air quality index; sources and types of pollutants (primary and secondary); smog (case study); effects of different pollutants on human health (NOx, SOx, PM, CO, CO2 hydrocarbons and VOCs); indoor air pollution: sources and effects on human health.
III	**Water pollution:** Sources of surface and ground water pollution; water quality parameters and standards; organic waste and water pollution; eutrophication; COD, BOD, DO; effect of water contaminants on human health (nitrate, fluoride, arsenic, chlorine, cadmium, mercury, pesticides); water borne diseases; concept and working of effluent treatment plants (ETPs).

IV	**Soil pollution:** Causes of soil pollution and degradation; effect of soil pollution on environment, vegetation and other life forms; control strategies, Effects of pesticides on human health.
V	**Noise pollution:** Noise pollution – sources; frequency, intensity; sound pressure level; sound intensity level and permissible ambient noise levels; effect on communication, impacts on life forms and humans - working efficiency, physical and mental health; control measures.
VI	**Radioactive and thermal pollution:** Radioactive material and sources of radioactive pollution; effect of radiation on human health (somatic and genetic effects); thermal pollution and its effects.
VII	**Marine pollution:** Marine resources and their importance; sources of marine pollution; oil spill and its effects; coral reefs and their demise; coastal area management; existing challenges and management techniques (planning, construction, environmental monitoring of coastal zones).
VIII	**Chemistry of environmental pollutants:** Solubility of pollutants (hydrophilic and lipophilic pollutants), transfer of pollutants within different mediums, role of chelating agents in transferring pollutants, concept of biotransformation and bioaccumulation, concept of radioactivity, radioactive decay and half- life of pollutants, organometallic compounds, acid mine drainage.
IX	**Pollution control:** Waterwater treatment- Activated Sludge Process (ASP) – Trickling Filters – oxidation ponds, fluidized bed reactors, membrane bioreactor neutralization, ETP sludge management; digesters, up flow anaerobic sludge blanket reactor, fixed film reactors, sequencing batch reactors, hybrid reactors, bioscrubbers, biotrickling filters; regulatory framework for pollution monitoring and control; case study: Ganga Action Plan; Yamuna Action Plan;implementation of CNG in NCT of Delhi. Methods for treatment of drinking water - aeration, flocculation, sedimentation, filtration, and disinfection Air pollution control measures for PM (gravitational settling chambers, centrifugal collector, wet scrubber, bag house filter and ESP); for gaseous pollutant (absorption, adsorption, condensation and combustion);

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text and Reference Books:

1. "Environmental Health: From Global to Local" by Howard Frumkin, published by John Wiley &Sons

2. “Toxicology and Risk Assessment: Principles, Methods, and Applications” by Ronald E. Baynes, published by John Wiley &Sons
3. “Environmental Pollution and Control” by P. Aarne Vesilind, Susan M. Morgan, and Laurence R. Shemilt, published by Butterworth-Heinemann
4. “Environmental Science: Earth as a Living Planet” by Daniel B. Botkin and Edward A. Keller, published by John Wiley & Sons
5. “Principles of Environmental Toxicology” by I. L. Androutsopoulos, published by CRC Press
6. “Environmental Health: Third Edition” by Dade W. Moeller, published by Harvard University Press
7. “Environmental Health: From the Global to the Local” by Howard Frumkin, published by John Wiley & Sons
8. “Introduction to Environmental Toxicology: Molecular Substructures to Ecological Landscapes” by Wayne G. Landis, Ruth M. Sofield, and Ming-Ho Yu, published by CRC Press
9. “Environmental Health: New Directions” by Bernard D. Goldstein, Mary Sue Henifin, and Christine Coussens, published by National Academies Press.
10. “Environmental Pollution: Health and Toxicology” by S. K. Srivastava and K. C. Gupta, published by CRC Press.

Analytical methods, instrumentation, and Measurement

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	V
Course Title	Analytical methods, Instrumentation and Measurement
Course Code	EVS11228

Credit	4
Contact Hours (L-T-P)	4-0-0
Course Type	Theory
Course Objective	The objectives of this course are • To introduce students to the fundamental principles of analytical chemistry and its application to environmental analysis. • To provide students with an understanding of the principles and operation of various analytical instruments used in environmental analysis. • To develop students' skills in sample preparation and handling for various environmental matrices. • To familiarize students with a variety of environmental analysis methods, including chromatography, spectrometry, and electrochemistry. • To teach students how to interpret and evaluate analytical data, and communicate scientific results effectively.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Understand the fundamental principles of analytical chemistry and their application to environmental analysis. **CO2:** Demonstrate proficiency in the operation of various analytical instruments and techniques used in environmental analysis. **CO3:** Develop skills in sample preparation and handling for various environmental matrices. **CO4:** Analyse environmental samples using a variety of analytical techniques, including chromatography, spectrometry, and electrochemistry. **CO5:** Interpret and evaluate analytical data, and communicate scientific results effectively.

Course Outline

Unit	Description
I	**Qualitative and quantitative aspects of analysis:** Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of

	distribution if indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals.
II	**Titrimetric and Optical methods of analysis:** Sampling, preservation, storage techniques; Principles and applications of titrimetry (Acidimetry, Alkalimetry, Complexometry, Argentometry, Iodometry) gravimetry, potentiometry, conductimetry. Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law. Flame Atomic Absorption and Emission Spectrometry: Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner designs. Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water samples.
III	**Thermal and electroanalytical methods:** Theory of thermogravimetry (TG), basic principle of instrumentation techniques for quantitative estimation of Ca and Mg from their mixture. Electroanalytical methods: Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pKa values.
IV	**Separation techniques: 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. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media. Chromatography: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects of chromatographic methods of analysis: IC, GLC, GPC,TLC and HPLC**.**

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text and Reference Books:

1. Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery and others) 5th Ed. The English Language Book Society of Longman.

2. Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
3. Christian, Gary D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York,2004.
4. Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.
5. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.
6. Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Thomson. Asia Pvt. Ltd

Environmental Economics and Statistics

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	V
Course Title	Environmental Economics and Statistics
Course Code	EVS11229
Credit	4
Contact Hours (L-T-P)	4-0-0
Course Type	DSE I Theory
Course Objective	The objectives of this course are • Understand the economic principles that govern environmental decision-making, such as externalities, market failures, and public goods. • Understand the economic tools and methodologies used to evaluate environmental policies and programs, such as cost-benefit analysis, input-output analysis, and environmental valuation.

	• Develop proficiency in using statistical tools and techniques to Analyse and interpret environmental data, including regression analysis, hypothesis testing, and sampling techniques. • Evaluate the economic and environmental impacts of policies and regulations, such as emissions trading, pollution taxes, and renewable energy standards. • Understand the key drivers of environmental degradation, including population growth, technological change, and institutional arrangements, and develop strategies to address them. • Analyse case studies of successful and unsuccessful environmental policies and programs, and apply these lessons to the design of new policies and programs. • Develop skills in written and oral communication of economic and statistical concepts, both to technical and non-technical audiences.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Understand the basic principles of environmental economics and their application to environmental decision-making. **CO2:** Develop proficiency in using statistical tools and techniques to Analyse and interpret environmental data. **CO3:** Evaluate the economic and environmental impacts of policies and regulations, such as emissions trading, pollution taxes, and renewable energy standards. **CO4:** Analyse case studies of successful and unsuccessful environmental policies and programs, and apply these lessons to the design of new policies and programs. **CO5:** Develop skills in written and oral communication of economic and statistical concepts, both to technical and non-technical audiences.

Course Outline

Unit	Description
I	**Environmental economics:** Main characteristics of environmental goods; marginal analysis; markets and market failure; social benefit, costs and welfare functions; meaning and types of environmental values; measures of economic values; tangible and intangible benefits; Pareto principle or criterion; Hardin's Thesis of 'The Tragedy of Commons';

	prisoner's dilemma game; methods of abatement of externalities; social cost benefit analysis; cost-effectiveness analysis; Contingent Valuation; Hedonic Pricing; Concept of travel Cost method.
II	**Natural resource economics:** Economics of non-renewable resources; economics of fuels and minerals; Hotelling's rule and extensions; taxation; economics of renewable resources; economics of water use, management of fisheries and forests; introduction to natural resource accounting.
III	**Economic solutions to environmental problems:** Social costs and benefits of environmental programmes: marginal social benefit of abatement, marginal social cost of abatement; pollution control: policies for controlling air and water pollution, disposal of toxic and hazardous waste- standards vs. emissions charges, environmental subsidies, modelling and emission charges; polluter pay principles; pollution permit trading system.
IV	**Tools for environmental economic policy:** Growth and environment; environmental audit and accounting, Kuznets curve, environmental risk analysis, assessing benefits and cost for environmental decision making; cost benefit analysis and valuation: discounting, principles of Cost-Benefit Analysis, estimation of costs and benefits, techniques of valuation, adjusting and comparing environmental benefits and costs.
V	**Statistical techniques applied to Environmental systems:** Variables, population and Sampling, sampling methods, sampling error, frequency distribution, bar diagram, pie diagram, arithmetic and geometric mean, mode, median, measures of deviation, null and alternative hypothesis, probability distribution, t-test, $\chi 2$ Test, f-test, correlation and regression.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text and Reference Books:

1. Arrow, K., Bolin, B., Costanza, R., Dasgupta, P., Folke, C., Holling, C.S., Jansson, B.O., Levin, S., Maler, K.G., Perrings, C., Pimentel, D. 1995. Economic growth, carrying capacity, and the environment. Ecological Economics 15: 91-95.
2. Hanley, N., Shogren, J. F., & White, B. 2007. Environmental Economics: In Theory and Practice. Palgrave Macmillan.
3. Kolstad, C.D. 2010. Environmental Economics. Oxford University Press.

4. Perman, R. 2003. Natural Resource and Environmental Economics. Pearson Education.
5. Singh, K. & Shishodia, A. 2007. Environmental Economics: Theory and Applications. Sage Publications.
6. Thomas, J.M. & Callan, S.J. 2007.Environmental Economics. Thomson Learning Inc.
7. Tietenberg, T. 2004. Environmental and Natural Resource Economics (6th Edition) Pearson Education Pvt. Ltd.
8. Tietenberg, T. H. & Lewis, L. 2010. Environmental Economics and Policy. Addison-Wesley.

Solid Waste Management

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	V
Course Title	Solid Waste Management
Course Code	EVS11230
Credit	4
Contact Hours (L-T-P)	4-0-0
Course Type	DSE I Theory
Course Objective	The objectives of this course are • To understand the basic concepts of solid waste management, including types of waste, sources of waste, and waste generation rates. • To examine the environmental, social, and economic impacts of improper solid waste management practices.

	• To learn about the various stages of solid waste management, including collection, transportation, treatment, and disposal. • To explore the different types of solid waste treatment and disposal methods, such as landfilling, incineration, composting, and recycling. • To study the principles of waste reduction and waste minimization, including the 3Rs (reduce, reuse, and recycle) approach. • To evaluate the effectiveness of different solid waste management strategies, policies, and regulations at the local, regional, and national levels. • To develop skills in solid waste management planning, including waste characterization, waste stream analysis, and waste management hierarchy. • To Analyse case studies of successful and unsuccessful solid waste management programs, and apply these lessons to the design of new programs. • To understand the emerging trends and challenges in solid waste management, including e-waste, hazardous waste, and plastic pollution. • To develop critical thinking and problem-solving skills in addressing solid waste management issues and promoting sustainable waste management practices.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Identify the sources, types, and quantities of solid waste generated by human activities, and explain the environmental, social, and economic impacts of improper waste management practices. **CO2:** Evaluate the effectiveness of different solid waste management strategies, policies, and regulations, including waste reduction, reuse, recycling, composting, and landfilling. **CO3:** Develop skills in solid waste management planning, including waste characterization, waste stream analysis, and waste management hierarchy, and apply these skills to design and implement effective and sustainable solid waste management programs. **CO4:** Analyse emerging trends and challenges in solid waste management, such as e- waste, hazardous waste, and plastic pollution, and develop strategies to address these challenges. **CO5:** Demonstrate the ability to communicate effectively with stakeholders, including government officials, community

	members, and industry leaders, about the importance of solid waste management and the benefits of sustainable waste management practices.

Course Outline

Unit	Description
I	**Introduction:** Sources and generation of solid waste, their classification and chemical composition; characterization of municipal solid waste; hazardous waste and biomedical waste.
II	**Effect of solid waste disposal on environment:** Impact of solid waste on environment, human and plant health; effect of solid waste and industrial effluent discharge on water quality and aquatic life; mining waste and land degradation; effect of land fill leachate on soil characteristics and ground water pollution.
III	**Solid waste Management:** Different techniques used in collection, storage, transportation and disposal of solid waste (municipal, hazardous and biomedical waste); landfill (traditional and sanitary landfill design); thermal treatment (pyrolysis and incineration) of waste material; drawbacks in waste management techniques.
IV	**Industrial waste management:** Types of industrial waste: hazardous and non-hazardous; effect of industrial waste on air, water and soil; industrial waste management and its importance; stack emission control and emission monitoring; effluent treatment plant and sewage treatment plant.
V	**Resource Recovery:** 4R's - reduce, reuse, recycle and recover; biological processing - composting, anaerobic digestion, aerobic treatment; reductive dehalogenation; mechanical biological treatment; green techniques for waste treatment.
VI	**Waste-to-energy (WTE):** Concept of energy recovery from waste; refuse derived fuel (RDF); different WTE processes: combustion, pyrolysis, landfill gas (LFG) recovery; anaerobic digestion; gasification.
VII	**Integrated waste management**: Concept of Integrated waste management; waste management hierarchy; methods and importance of Integrated waste management.
VIII	**Policies for solid waste management:** Municipal Solid Wastes (Management and Handling) Rules 2016; Hazardous and other Wastes (Management and Transboundary Movement) 2016; Bio-Medical Waste Management Rules 2016; Plastic Waste Management Rules, 2016 and Plastic Waste Management (Amendment) Rules, 2018; E-Waste (Management) Rules, 2016 and E- Waste (Management) Amendment Rules, 2018.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text and Reference Books:

1. Asnani, P. U. 2006. Solid waste management. India Infrastructure Report 570.
2. Bagchi, A. 2004. Design of Landfills and Integrated Solid Waste Management. John Wiley & Sons.
3. Blackman, W.C. 2001. Basic Hazardous Waste Management. CRC Press.
4. McDougall, F. R., White, P. R., Franke, M., & Hindle, P. 2008. Integrated Solid Waste Management: A Life Cycle Inventory. John Wiley & Sons.
5. US EPA. 1999. Guide for Industrial Waste Management. Washington D.C.
6. White, P.R., Franke, M. &Hindle P. 1995. Integrated Solid waste Management: A Lifecycle Inventory. Blackie Academic & Professionals.
7. Zhu, D., Asnani, P.U., Zurbrugg, C., Anapolsky, S. & Mani, S. 2008. Improving Municipal Solid waste Management in India. The World Bank, Washington D.C.

Green Technologies

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	V
Course Title	Green Technologies
Course Code	EVS11231
Credit	4
Contact Hours (L-T-P)	4-0-0
Course Type	DSE II Theory
Course Objective	The objectives of this course are • Understanding the principles of sustainability and their application in technology.

	• Exploring various green technologies, such as renewable energy systems, energy- efficient buildings, and sustainable transportation systems. • Analysing the environmental impact of current technologies and identifying areas for improvement. • Learning how to design and implement sustainable solutions in various industries. • Studying the economics of green technologies and their potential for creating new business opportunities. • Examining government policies and regulations related to green technologies and their impact on industry. • Developing critical thinking and problem-solving skills to address complex sustainability issues. • Collaborating with peers to create innovative green technology solutions. • Understanding the ethical considerations and social implications of green technologies. • Communicating effectively about green technologies to diverse audiences, including stakeholders, policymakers, and the general public.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Identify and describe various types of green technologies and their applications, including renewable energy sources, energy efficiency technologies, and sustainable materials. **CO2:** Evaluate the economic, environmental, and social benefits and drawbacks of different green technologies, and compare them to traditional technologies. **CO3:** Analyse the policy and regulatory framework surrounding green technologies, including government incentives and regulations, and assess their impact on the adoption and diffusion of green technologies. **CO4:** Develop skills in assessing the environmental impact of green technologies, including life cycle assessment and carbon footprint analysis, and use this information to make informed decisions about the adoption and implementation of green technologies. **CO5:** Apply knowledge and skills learned in the course to design and implement green technology solutions for real-world environmental challenges, and effectively communicate the benefits and limitations of these solutions to stakeholders.

Course Outline

Unit	Description
I	**Introduction:** Definition and concepts: green technology, green energy, green infrastructure, green economy, and green chemistry; sustainable consumption of resources; individual and community level participation such as small-scale composting pits for biodegradable waste, energy conservation; encouraged use of public transport instead of private transport.
II	**Green technologies:** Green technologies in historical and contemporary perspectives; successful green technologies: wind turbines, solar panels; 3 R's of green technology: recycle, renew and reduce; paradigm shift from 'cradle to grave' to 'cradle to cradle'
III	**Green infrastructure, planning and economy:** Green buildings; history of green buildings, need and relevance of green buildings over conventional buildings, construction of green buildings; associated costs and benefits; outlined examples of green buildings; LEED certified building; Eco-mark certification, establishment of Eco-mark in India, its importance and implementation; Green planning: role of governmental bodies, land use planning, concept of green cities, waste reduction and recycling in cities, role of informal sector in waste management, public transportation for sustainable development, green belts. ; Introduction to UNEP's green economy initiative, inclusive economic growth of the society, REDD+ initiative, and cap and trade concept; green banking.
IV	**Applications of green technologies: 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).
V	**Green chemistry:** Introduction to green chemistry; principles and recognition of green criteria in chemistry; biodegradable and bio-accumulative products in environment; green nanotechnology; reagents, reactions and technologies that should be and realistically could be replaced by green alternatives; photodegradable plastic bags.
VI	**Green future:** Agenda of green development; reduction of ecological footprint; role of green technologies towards a sustainable future; major challenges and their resolution for implementation of green technologies; green practices to conserve natural resources (organic agriculture, agroforestry, reducing paper usage and consumption, etc.); emphasis on waste reduction instead of recycling, emphasis on innovation for green future; role of advancement in science in developing environmental friendly technologies.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text and Reference Books:

1. Anastas, P.T. & Warner, J.C. 1998. Green Chemistry: Theory & Practice. Oxford University Press.
2. Arceivala, S.L. 2014. Green Technologies: For a Better Future. Mc-Graw Hill Publications.
3. Baker, S. 2006. Sustainable Development. Routledge Press.
4. Hrubovcak, J., Vasavada, U. & Aldy, J. E. 1999. Green technologies for a more sustainable agriculture (No. 33721). United States Department of Agriculture, Economic Research Service.
5. Thangavel, P. & Sridevi, G. 2015. Environmental Sustainability: Role of Green Technologies. Springer Publications.
6. Woolley, T. & Kimmins, S. 2002. Green Building Handbook (Volume 1 and 2). Spon Press.

Urban Ecosystems

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	V
Course Title	Urban Ecosystems
Course Code	EVS11231

Credit	4
Contact Hours (L-T-P)	4-0-0
Course Type	DSE II Theory
Course Objective	The objectives of this course are • Understanding the concepts and principles of urban ecosystems. • Examining the ecological and environmental issues associated with urbanization. • Exploring the interactions between urban ecosystems, natural ecosystems, and human systems. • Identifying the challenges of managing and sustaining urban ecosystems. • Analyzing the impacts of urbanization on biodiversity, natural resources, and ecosystem services. • Learning about urban planning and design strategies that promote sustainable urban ecosystems. • Studying the social and cultural aspects of urban ecosystems and their role in shaping urban communities. • Developing critical thinking and problem-solving skills to address complex urban ecosystem issues. • Collaborating with peers to propose and develop sustainable solutions for urban ecosystem management. • Communicating effectively about urban ecosystem issues and solutions to diverse audiences, including stakeholders, policymakers, and the general public.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Understand the characteristics and functions of urban ecosystems. **CO2:** Analyse the impact of urbanization on natural ecosystems and biodiversity. **CO3:** Evaluate the role of urban planning and design in creating sustainable urban ecosystems. **CO4:** Critically assess the challenges and opportunities in managing urban ecosystems for human well-being and environmental sustainability. **CO5:** Develop strategies and solutions for improving the resilience and sustainability of urban ecosystems.

Course Outline

Unit	Description
I	**Introduction:** Introduction to urbanization; urban sprawl and associated environmental issues.
II	**Environment in an urban setting:** Man as the driver of urban ecosystem; commodification of nature; metros, cities and towns as sources and sinks of resources; resource consumption and its social, cultural, economic and ecological perspectives; urban transformation; increasing challenges posed by modernity for the environment; urban pollution (air, water, soil).
III	**Urban dwelling:** Housing scenario across a range of large-medium-small cities; poverty and slums in an urban context; Town planning Acts and their environmental aspects; energy consumption and waste disposal as well as accumulation; environmental costs of urban infrastructure.
IV	**Urban interface with the environment:** Management of urban environment; alternative resources; policy and management decisions; urban settings as loci of sustainability; challenges associated with sustainability and urban future.
V	**Natural spaces in a city:** Concept of 'controlled nature'; scope, importance and threats to nature in the city; organization and planning of green spaces such as parks, gardens and public spaces; concept of green belts; urban natural forest ecosystem as green lungs.
VI	**Planning and environmental management:** Urban planning and its environmental aspects from historical and contemporary perspectives; benefits of environmental management; introduction to green buildings; urban governance; political complexity of applying ecological science to urban policy and planning, smart cities.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text and Reference Books:

1. D'Monte, Darryl. 1985. Industry versus Environment Temples or Tombs. Three Controversies,Delhi, CSE.
2. Ernstson, H. 2011. Re-translating nature in post-apartheid Cape Town: The material semiotics ofpeople and plants at Bottom Road. In: Heeks, R., (Ed.) Conference on

"UnderstandingDevelopment through Actor-Network Theory", London School of Economics, 30 June, London.

3. Gaston, K.J. 2010. Urban Ecology. Cambridge University Press, New York.
4. Grimm, N. B., Faeth, S. H., et al. 2008. Global Change and the Ecology of Cities. Science 319:756-760.
5. Hinchliffe, S. & Whatmore, S. 2006. Living cities: Towards a politics of conviviality Science asCulture 15: 123–138.
6. McIntyre, N.E. 2000. Urban ecology as an interdisciplinary field: differences in the use of 'urban'between the social and natural sciences. Urban Ecosystems 4: 5-24.
7. Montgomery, M.R. 2009. Urban Transformation of the developing world. Science 319: 761-764.
8. Richter, M. & Weiland, U. (ed.). 2012. Applied Urban Ecology. Wiley-Blackwell, UK.

Environmental Pollution and Human health Lab

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	V
Course Title	Environmental Pollution and Human health Lab
Course Code	EVS12233
Credit	2
Contact Hours (L-T-P)	0-0-3
Course Type	Practical
Course Objective	The objectives of this course are • Understanding the basic principles and concepts of environmental pollution and its effects on human health.

	• Gaining practical experience in the measurement and analysis of environmental pollutants such as air pollutants, water pollutants, and soil pollutants. • Understanding the sampling and analytical techniques used to measure environmental pollutants. • Analyzing the data obtained from environmental samples and interpreting the results. • Identifying potential sources of environmental pollution and developing strategies to mitigate their effects on human health. • Understanding the regulatory frameworks and policies related to environmental pollution and human health. • Developing skills in laboratory safety and good laboratory practices. • Enhancing critical thinking skills by evaluating scientific literature related to environmental pollution and human health. • Developing effective communication skills through presenting and discussing laboratory findings and scientific literature.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Demonstrate an understanding of the principles and concepts of environmental pollution and its impact on human health. **CO2:** Apply sampling and analytical techniques to measure environmental pollutants, such as air pollutants, water pollutants, and soil pollutants. **CO3:** Analyse and interpret laboratory data obtained from environmental samples. **CO4:** Develop strategies for mitigating the effects of pollution on human health and the environment. **CO5:** Demonstrate effective communication skills by presenting and discussing laboratory findings and scientific literature related to environmental pollution and human health.

Course Outline

Unit	Description
I	1. Estimation of Ground & surface water quality parameters (COD, BOD, DO, nitrate, fluoride, arsenic, chlorine, cadmium, mercury, pesticides). 2. Estimation of air quality parameters (NOx, SOx, SPM). 3. Field visit to effluent treatment plants (ETP)/ sewage treatment plants (STP)

	4. Total coliform load of water sample. 5. Noise monitoring (Leq).

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Analytical methods, instrumentation, and Measurement Lab

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	V
Course Title	Analytical methods, instrumentation, and Measurement Lab
Course Code	EVS12234
Credit	2
Contact Hours (L-T-P)	0-0-3
Course Type	Practical
Course Objective	The objectives of this course are • Understanding the principles of analytical chemistry and their application to environmental analysis. • Familiarizing students with commonly used analytical instruments and their functions, including spectrophotometers, chromatographs, and mass spectrometers.

	• Developing skills in the selection, use, and maintenance of laboratory instruments for environmental analysis. • Introducing students to the principles and techniques of sampling and sample preparation for environmental analysis. • Providing hands-on experience with laboratory techniques for environmental analysis, including wet chemistry techniques, chromatography, and spectrophotometry. • Developing skills in data analysis and interpretation of environmental analytical results. • Emphasizing laboratory safety, good laboratory practices, and quality control/quality assurance in environmental analysis. • Developing critical thinking skills and problem-solving abilities through practical laboratory exercises. • Familiarizing students with relevant environmental regulations and policies and their implications for environmental analysis. • Preparing students for careers in environmental monitoring and analysis, research, and regulatory compliance.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Understand the principles of analytical chemistry and their application to environmental analysis. **CO2:** Develop skills in laboratory techniques for environmental analysis. **CO3:** Apply principles of sampling and sample preparation to environmental analysis. **CO4:**Analyse and interpret environmental analytical and evaluate the quality and reliability of these results. **CO5:**Practice good laboratory practices, including documentation, record-keeping, and quality control/quality assurance procedures.

Course Outline

Unit	Description
I	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 pKa 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.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Waste Management Site Visit

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	V
Course Title	Waste Management Site Visit
Course Code	EVS12235
Credit	2
Contact Hours (L-T-P)	0-0-3
Course Type	Practical
Course Objective	The objectives of this course are • To expose students to real-world waste management practices and technologies through a site visit.

	• To provide hands-on experience for students to develop practical skills in waste management and disposal. • To familiarize students with the legal and regulatory framework governing waste management. • To promote critical thinking and problem-solving skills by analyzing real-world waste management problems and challenges. • To foster an appreciation for the importance of sustainable waste management practices and their impact on the environment and society.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Gain a comprehensive understanding of the principles and practices of waste management through a waste management site visit. **CO2:** Develop practical skills in waste management and disposal by observing and participating in various waste management activities during the site visit. **CO3:** Understand the economic and social aspects of waste management, including costs, incentives, and social and cultural factors, through the site visit. **CO4:** Develop critical thinking and problem-solving skills in waste management by analyzing real-world waste management problems and challenges during the site visit. **CO5:** Gain an appreciation for the importance of sustainable waste management practices through the waste management site visit.

Course Outline

Unit	Description
I	Visit to a waste management site and preparation of field visit report.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Summer Internship/Environmental Camp

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	V
Course Title	Summer Internship/Environmental Camp
Course Code	EVS14236
Credit	2
Contact Hours (L-T-P)	-
Course Type	Practical
Course Objective	The objectives of this course are • To provide students with hands-on experience and practical skills in environmental conservation and sustainability. • To expose students to real-world environmental issues and challenges, such as climate change, pollution, and natural resource depletion. • To help students develop an understanding of the interconnections between the environment, society, and the economy. • To promote critical thinking and problem-solving skills by engaging students in environmental research, analysis, and decision-making. • To encourage students to become environmentally responsible citizens and advocates for sustainable development in their communities.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Gain practical skills and experience in environmental management practices through participation in an internship or camp program.

	CO2: Develop a comprehensive understanding of current environmental issues and their impact on society and the economy. **CO3:** Analyse and evaluate environmental data, research findings, and policy decisions to promote critical thinking and problem-solving skills. **CO4:** Identify and apply sustainable development principles and practices to environmental issues and challenges. **CO5:** Communicate effectively with peers, professionals, and the public regarding environmental issues, policies, and practices.

Course Outline

Unit	Description
I	Completion of at least month long industrial/academic internship or participation in a nature/wildlife/environmental camp (week long).

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Environmental Economics and Statistics Lab

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	V
Course Title	Environmental Economics and Statistics Lab
Course Code	EVS12237
Credit	2

Contact Hours (L-T-P)	0-0-3
Course Type	DSE I Practical
Course Objective	The objectives of this course are • To introduce students to the fundamental principles of environmental economics and their application to environmental management and policy. • To provide students with an understanding of the statistical tools and methods used in environmental data analysis and research. • To promote critical thinking and problem-solving skills by engaging students in environmental research and analysis. • To develop students' abilities to communicate environmental data and research findings effectively to diverse audiences. • To encourage students to apply their knowledge and skills to real-world environmental issues and challenges.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Develop a thorough understanding of environmental economics principles and their application to environmental management and policy. **CO2:** Gain proficiency in statistical tools and methods used in environmental data analysis and research. **CO3:** Acquire critical thinking and problem-solving skills through environmental research and analysis. **CO4:** Develop effective communication skills for presenting environmental data and research findings to diverse audiences. **CO5:** Apply environmental economics and statistical concepts and methods to real-world environmental issues and challenges.

Course Outline

Unit	Description
I	Numerical problems on biostatistics: Chi-Square test (Goodness of fit, Contingency), Student's t test (Paired and Unpaired). Analysis of Variance (ANOVA)
II	Valuation of a forest/wetland- model exercise based on field study.

III	Viva-voce & Laboratory Notebooks.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Solid Waste Management Lab

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	V
Course Title	Solid Waste Management Lab
Course Code	EVS12238
Credit	2
Contact Hours (L-T-P)	0-0-3
Course Type	DSE I Practical
Course Objective	The objectives of this course are • To provide students with hands-on experience in the management of solid waste, including collection, transportation, processing, and disposal. • To develop students' skills in the design and operation of solid waste management systems and technologies. • To familiarize students with the legal and regulatory framework governing solid waste management.

	• To promote critical thinking and problem-solving skills by analyzing real-world solid waste management problems and challenges. • To foster an appreciation for the importance of sustainable solid waste management practices and their impact on the environment and society.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Develop practical skills and knowledge in the management of solid waste, including collection, transportation, processing, and disposal. **CO2:** Design and operate solid waste management systems and technologies effectively. **CO3:** Understand the legal and regulatory framework governing solid waste management. **CO4:** Apply critical thinking and problem-solving skills to real-world solid waste management problems and challenges. **CO5:** Develop an appreciation for sustainable solid waste management practices and their impact on the environment and society.

Course Outline

Unit	Description
I	1. Sample Preparation and Sampling Techniques 2. Coning and Quartering Method 3. Profile sampling of municipal solid waste 4. Analysis of solid waste/ sludge for moisture content 5. Analysis of solid waste/ sludge for particle size 6. Analysis of solid waste/ sludge for calorific value 7. Visit to a Solid Waste Management site and Report submission. 8. Viva-voce.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Green Technologies Lab

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	V
Course Title	Green Technologies Lab
Course Code	EVS12239
Credit	2
Contact Hours (L-T-P)	0-0-3
Course Type	DSE II Practical
Course Objective	The objectives of this course are • To introduce students to various green technologies, including renewable energy systems, energy-efficient appliances, and green building materials. • To develop students' practical skills in the installation, operation, and maintenance of green technologies. • To promote critical thinking and problem-solving skills by analyzing real-world green technology challenges and opportunities. • To foster an understanding of the economic, social, and environmental benefits of green technologies. • To encourage students to consider the role of green technologies in addressing global environmental challenges, such as climate change and resource depletion.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Develop practical skills in the installation, operation, and maintenance of various green technologies. **CO2:** Understand the principles and applications of green technologies, including renewable energy systems, energy-efficient appliances, and green building

	materials. **CO3:** Analyse real-world green technology challenges and opportunities, and develop critical thinking and problem-solving skills to address them. **CO4:** Understand the economic, social, and environmental benefits of green technologies and their role in addressing global environmental challenges. **CO5:** Consider the social and ethical implications of green technologies and promote equitable access to green technology benefits.

Course Outline

Unit	Description
I	1. Worksheet preparation of schemes of different green processes and practices based on industry visit 2. Photocatalytic treatment of wastewater. 3. Designing a green building. 4. Study of degradability of plastics. 5. Preparation of biodiesel from vegetable oil. 6. Planning a rainwater harvesting protocol 7. Visit to biofertilizer, vermicomposting units, organic agriculture farms and report preparation.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Urban Ecosystems Lab

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	V

Course Title	Urban Ecosystems Lab
Course Code	EVS12240
Credit	2
Contact Hours (L-T-P)	0-0-3
Course Type	DSE II Practical
Course Objective	The objectives of this course are • To introduce students to the concept of urban ecosystems and the components that make them up. • To develop students' practical skills in assessing and monitoring urban ecosystems, including water quality, air quality, and soil quality. • To promote critical thinking and problem-solving skills by analyzing real-world urban ecosystem challenges and opportunities. • To foster an understanding of the social and ecological benefits of urban ecosystems. • To encourage students to consider the role of urban ecosystems in promoting sustainable development and resilience in urban areas.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Develop practical skills in assessing and monitoring the health and function of urban ecosystems, including water quality, air quality, and soil quality. **CO2:** Understand the concept of urban ecosystems and the components that make them up, including waterways, green spaces, and built structures. **CO3:** Analyse real-world urban ecosystem challenges and opportunities, and develop critical thinking and problem-solving skills to address them. **CO4:** Understand the social and ecological benefits of urban ecosystems and their role in promoting sustainable development and resilience in urban areas. **CO5:** Consider the social and ethical implications of urban ecosystem management and promote equitable access to urban ecosystem benefits.

Course Outline

Unit	Description
I	Field survey based analysis, exercise and interpretation Exercises: Students will carry out a group work in which the development of the infrastructure of the city of the future is explored and presented. The assignment concentrates on the development of one infrastructure (clean water, wastewater or energy) in two possible surroundings (newly built city or transition from present to future situation). Tutorial focusing on introducing the state-of-the-art technologies for drinking water supply, wastewater treatment, energy supply and material/nutrient recycling and recovery. Individual assignment the student will perform a technological assessment for the solution of a specific urban environmental problem performing basic calculations on urban flows and their transformations and considering the sustainability outcome. Field visits to experience various environmental technologies working in practice.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Program Outcome Vs Courses Mapping Table of Semester: VI

Course Code	Course Name	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
EVS11241	Environmental Legislation and Environmental Impact Assessment	CO1	2	2	3	3	2	1	2	1	3	3
		CO2	2	1	1	2	2	2	1	2	2	1
		CO3	3	2	2	1	2	2	2	2	2	2
		CO4	3	3	2	3	2	2	2	1	3	3
		CO5	3	2	1	2	3	3	1	3	1	2
		CO	2.6	2	1.8	2.2	2.2	2	1.6	1.8	2.2	2.2
EVS11242	Wastewater Engineering	**COs**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PSO1**	**PSO2**	**PSO3**
		CO1	2	2	1	3	2	1	2	1	1	2
		CO2	2	3	3	-	2	3	2	-	2	-
		CO3	3	2	1	2	3	1	2	2	2	2
		CO4	2	1	2	3	2	2	2	3	3	1
		CO5	3	2	2	3	3	1	2	2	-	2
EVS11243	Environmental Health and Toxicology	CO1	2	2	1	3	2	1	2	1	1	2
		CO2	3	1	3	-	2	3	2	-	2	-
		CO3	2	2	2	2	3	1	2	2	1	3
		CO4	2	3	1	1	2	2	3	1	2	1
		CO5	3	2	2	3	3	1	2	2	-	2
		CO	2.4	2	1.8	2.25	2.4	1.6	2.2	1.5	1.5	2
EVS11244	Remote Sensing and Geographic Information System	CO1	2	2	3	3	2	1	2	1	3	3
		CO2	2	3	1	2	2	2	1	2	2	1
		CO3	3	2	2	2	2	2	2	2	2	2
		CO4	3	3	3	3	2	2	2	2	3	3
		CO5	3	2	1	2	3	3	1	3	1	2
		CO	2.6	2.4	2	2.4	2.2	2	1.6	2	2.2	2.2
EVS11245	Environmental data analytics	CO1	2	2	3	3	2	1	2	1	3	3
		CO2	2	3	1	2	2	2	1	2	2	1
		CO3	3	2	2	2	2	2	2	2	2	2
		CO4	3	3	3	3	2	2	2	2	3	3
		CO5	3	2	1	2	3	3	1	3	1	2
		CO	2.6	2.4	2	2.4	2.2	2	1.6	2	2.2	2.2

Correlation level 1, 2 and 3 as defined below:

"1" – Slight (Low)
"2" - Moderate (Medium)
"3" – Substantial (High)
"-" – No correlation

School of Basic and Applied Sciences
BSc (Hons) Environmental Science
Batch: 2022-23
Semester: VI

S. No.	Type of Course	Course Code	Course Title	Teaching Load				CREDITS
				L	T	P	TOTAL	
1	Core Theory	EVS11241	Environmental Legislation and Environmental Impact Assessment	4	0	0	4	4
2	DSE III Theory	EVS11242	Wastewater Engineering	4	0	0	4	4
		OR						
		EVS11243	Environmental Health and Toxicology					
3	DSE IV Theory	EVS11244	Remote Sensing and Geographic Information System	4	0	0	4	4
		OR						
		EVS11245	Environmental data analytics					
4	DSE III Practical	EVS12246	Wastewater Engineering	0	0	3	3	2
		OR						
		EVS12247	Environmental Health and Toxicology					
5	DSE IV Practical	EVS12248	Remote Sensing and Geographic Information System	0	0	3	3	2
		OR						
		EVS12249	Environmental Data Analytics lab					
6	Core Practical/ Dissertation Project	EVS15250	Dissertation Project and Viva voce	0	0	0	0	4
			Total	**12**	**0**	**6**	**18**	**20**

Environmental Legislation and Policy

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	VI
Course Title	Earth and Earth Surface Processes
Course Code	EVS11241
Credit	4
Contact Hours (L-T-P)	4-0-0
Course Type	Theory
Course Objective	The objectives of this course are • To provide an overview of the major environmental laws and policies at the local, national, and international levels. • To develop an understanding of the principles and processes involved in environmental policymaking and implementation. • To explore the economic, social, and environmental implications of environmental laws and policies. • To examine the role of different stakeholders, including government agencies, industry, and civil society organizations, in environmental policymaking. • To promote critical thinking and problem-solving skills by analyzing real-world environmental policy challenges and opportunities.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Develop an understanding of the major environmental laws and policies at the local, national, and international levels, and their impact on environmental protection and sustainability. **CO2:** Understand the principles and processes involved in environmental policymaking and implementation, and the role of

	different stakeholders, including government agencies, industry, and civil society organizations. **CO3:** Analyse the economic, social, and environmental implications of environmental laws and policies, and assess their effectiveness in achieving environmental goals. **CO4:** Evaluate the strengths and weaknesses of key environmental laws and policies, and identify opportunities for improvement and innovation. **CO5:** Apply critical thinking and problem-solving skills to Analyse real-world environmental policy challenges and opportunities, and propose strategies for effective environmental policy development and implementation.

Course Outline

Unit	Description
I	**History of environmental legislation and policy:** Ancient period: worship of water, air, trees; Mauryan period: Kautilya's Arthashastra, Yajnavalkyasmriti and Charaksamhita; Medieval period: forests as woodland and hunting resourcesduring Mughal reign; British India: Indian Penal Code 1860, Forest Act 1865,Fisheries Act 1897; Independent India: Van Mahotsava 1950, National Forest Policy 1952, Orissa River pollution and prevention Act 1953.
II	**Environmental legislation:** Constitution of India; fundamental rights; fundamental duties; Role of Ministry of Environment, Forests & Climate Change in environmental law and policy making; role of central and state pollution control boards and panchayats and municipal bodies in environmental law and policy making. Legal definitions (environmental pollution, natural resource, biodiversity, forest, sustainable development); Article 48A (The protection and improvement of environment and safeguarding of forests and wildlife); Article 51 A (Fundamental duties). The Indian Forest Act 1927; The Wildlife (Protection) Act 1972; The Water (Prevention and Control of Pollution) Act 1974; The Forests (Conservation) Act 1980; The Air (Prevention and Control of Pollution) Act 1981; The Environment (Protection) Act 1986; Motor Vehicle Act 1988; The Public Liability Insurance Act 1991; Noise Pollution (Regulation and Control) Rules 2000; The Biological Diversity Act 2002; The Schedule Tribes and other Traditional Dwellers (Recognition of Forests Rights) Act 2006; The National Green Tribunal Act 2010; scheme and labeling of environment friendly products, Concept of Ecomark and Ecolabelling.Case studies: National Green Tribunal: Aditya N Prasad vs. Union of India & Others; Ganga Tanneries Case: M.C. Mehta vs. Union of India 1988; environmental education case: M.C. Mehta vs. Union of India, WP 860/1991. Waste Management Rules 2016.
III	**International laws and policy:** Stockholm Conference 1972; United Nations Conference on Environment and Development 1992; Rio de Janeiro (Rio Declaration, Agenda 21); Montreal Protocol 1987; Kyoto Protocol 1997; Outcomes of recent United

	Nations Climate Change Conferences (COPs); Ramsar convention. Basel Convention; Climate change and policy; Environmental policy debate; International agreements; Montreal protocol 1987; Kyoto protocol 1997; Convention on Climate Change; carbon credit and carbon trading; clean development mechanism.
IV	**International laws and policy:** Stockholm Conference 1972; United Nations Conference on Environment and Development 1992; Rio de Janeiro (Rio Declaration, Agenda 21); Montreal Protocol 1987; Kyoto Protocol 1997; Outcomes of recent United Nations Climate Change Conferences (COPs); Ramsar convention. Basel Convention; Climate change and policy; Environmental policy debate; International agreements; Montreal protocol 1987; Kyoto protocol 1997; Convention on Climate Change; carbon credit and carbon trading; clean development mechanism. Case study of hydropower projects/ thermal projects. Rapid EIA; Strategic Environmental Assessment; Social Impact Assessment; Cost-Benefit analysis; Life cycle assessment; environmental appraisal; environmental management - principles, problems and strategies; environmental planning; environmental audit; introduction to ISO and ISO14000; sustainable development.
V	**Risk assessment:** Introduction and scope; project planning; exposure assessment; toxicity assessment; hazard identification and assessment; risk characterization; risk communication; environmental monitoring; community involvement; legal and regulatory framework; human and ecological risk assessment. Concept of Ecomark and Ecolabelling.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text and Reference Books:

1. Abraham, C.M. 1999. Environmental Jurisprudence in India. Kluwer Law International.

2. Agarwal, V.K. 2005. Environmental Laws in India: Challenges for Enforcement. Bulletin of the National Institute of Ecology 15: 227-238.

3. Divan, S. & Rosencranz, A. 2001. Environmental Law and Policy in India. Oxford University Press.

4. Divan, S. & Rosencranz, A. 2002. Environmental Law and Policy in India: Cases, Materials and Statues (2nd edition). Oxford University Press.

5. Gupta, K.R. 2006. Environmental Legislation in India. Atlantic Publishers an Distributors.
6. Leelakrishnan, P. 2008. Environmental Law in India (3rd edition). Lexis Nexis India.
7. Naseem, M. 2011. Environmental Law in India Mohammad. Kluwer Law International.
8. Venkat, A. 2011. Environmental Law and Policy. PHI Learning Private Ltd.
9. Barrow, C.J. 2000. Social Impact Assessment: An Introduction. Oxford University Press.
10. Glasson, J., Therivel, R., Chadwick, A. 1994. Introduction to Environmental Impact Assessment. London, Research Press, UK.
11. Judith, P. 1999. Handbook of Environmental Impact Assessment. Blackwell Science.
12. Marriott, B. 1997. Environmental Impact Assessment: A Practical Guide. McGraw Hill, New York, USA.

Wastewater Engineering

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	VI
Course Title	Wastewater Engineering
Course Code	EVS11242
Credit	4
Contact Hours (L-T-P)	4-0-0
Course Type	DSE III Theory
Course Objective	The objectives of this course are • To provide an overview of the principles and processes involved in wastewater treatment and management.

	• To develop an understanding of the sources and characteristics of wastewater, and the environmental and public health risks associated with untreated wastewater. • To explore the different wastewater treatment technologies and their design criteria, including physical, chemical, and biological processes. • To understand the role of wastewater treatment in promoting sustainable development and protecting the environment and public health. • To develop critical thinking and problem-solving skills by analyzing real-world wastewater engineering challenges and opportunities.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Develop an understanding of the sources and characteristics of wastewater, and the environmental and public health risks associated with untreated wastewater. **CO2:** Understand the principles and processes involved in wastewater treatment, including physical, chemical, and biological processes, and the design criteria for different wastewater treatment technologies. **CO3:** Analyse the strengths and weaknesses of different wastewater treatment technologies, and assess their potential for improving wastewater treatment efficiency and sustainability. **CO4:** Evaluate the role of wastewater treatment in promoting sustainable development and protecting the environment and public health, and identify opportunities for innovation and resource recovery. **CO5:** Apply critical thinking and problem-solving skills to Analyse real-world wastewater engineering challenges and opportunities, and propose strategies for improving wastewater treatment efficiency and sustainability.

Course Outline

Unit	Description
I	**Basics of wastewater treatment:** Physical, chemical and biological characteristics of wastewater.
II	**Preliminary and primary treatment:** Analysis and selection of wastewater flow rates and constituent loadings for process design. Physical unit operations: Screening, grit chamber, sedimentation and air flotation. Chemical unit operations: coagulation, precipitation, chemical oxidation and scale control.

III	**Secondary Treatment:** Biological treatment introduction, biomass growth kinetics. Advanced wastewater treatment: nutrient removal – Nitrogen and phosphorus removal, activated sludge processes and attached growth processes.
IV	**Advanced Secondary Treatment:** Anaerobic treatment processes, sludge treatment and disposal: sources, characteristics and quantities of sludge. Treatment processes, gravity and flotation thickening, sludge digestion, vacuum and pressure filtration. Ultimate sludge disposal.
V	**Tertiary Treatment:** Advanced treatment through membrane technology, MBR, MBBR technologies.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text and Reference Books:

1. Metcalf and Eddy, "Wastewater Engineering", 4th edition, McGraw-Hill, 2003.
2. Viessman and Hammer, "Water Pollution and Control", 7th edition, Pearson Prentice Hall, 2004.
3. Hammer M.J. (2000): Water and wastewater technology. Prentice Hall of India Pvt. Ltd., New Delhi.
4. Henze Harremoes La Cour Jansen, Arvin (1998): Wastewater treatment. Prentice Hall of India, USA.
5. Bristle, L.R. (1997): Theory and principles of water and wastewater treatment. John Willey and Sons, New Delhi.
6. Woodard, F. (2001): Industrial Waste Treatment Handbook. Butterworth Heinemonn, New Delhi.

Environmental Health And Toxicology

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	VI
Course Title	Environmental Health And ToxicologyWastewater Engineering
Course Code	EVS11243
Credit	4
Contact Hours (L-T-P)	4-0-0
Course Type	DSE III Theory
Course Objective	The objectives of this course are • To provide an understanding of the relationship between environmental quality and human health. • To introduce students to the principles of toxicology, including exposure assessment, dose-response relationships, and risk assessment. • To explore the sources and fate of environmental contaminants, including air pollutants, water pollutants, and hazardous wastes. • To examine the health effects associated with exposure to environmental contaminants, including acute and chronic effects, and the role of environmental factors in the development of chronic diseases. • To develop critical thinking and problem-solving skills by analyzing real-world environmental health challenges and opportunities.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Develop a comprehensive understanding of the relationship between environmental quality and human health, and the principles of toxicology, including exposure assessment, dose-response relationships, and risk assessment.

	CO2: Evaluate the sources and fate of different environmental contaminants, including air pollutants, water pollutants, and hazardous wastes, and the associated health effects of exposure to them. **CO3:** Analyse the toxicity of different environmental contaminants and the potential risks associated with exposure to them. **CO4:** Evaluate the role of different stakeholders, including government agencies, industry, and civil society organizations, in promoting environmental health and preventing exposure to environmental contaminants. **CO5:** Develop critical thinking and problem-solving skills to address real-world environmental health challenges and opportunities, and propose strategies for promoting environmental health and preventing exposure to environmental contaminants.

Course Outline

Unit	Description
I	**Epidemiology and Health:** Concept of Health and Disease, principles of epidemiology and epidemiological methods, aims of epidemiology, measurement of mortality, measurement of morbidity**.**
II	**Concept of Disease:** Concept of screening the diseases, some communicable diseases like smallpox, cholera, acute diarrheal disease, viral hepatitis, water borne pathogens, vector borne diseases, diseases caused by contaminated food and water, soil borne infections, insect borne diseases.
III	**Concept of Immunology:** Elementary idea about antigens and antibody, hypersensitivity, allergic reactions, pollens and their allergens. Immunological techniques.
IV	**Community and Health:** Communication for health education, health care of the country.
V	**Basic Concept of Toxicology:** Different types of toxicants, toxicity test, toxicity by different factors, exposure effect relationship, effects of heavy metals and metalloids on health, different route of exposure, synergistic and antagonistic effect, Biotransformation, bioaccumulation and Biomagnification. Detoxification, toxicodynamics; Basic concepts of toxicological assays (Eg. Comet Assay)

Evaluation:

Mode of Evaluation	Theory

Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text and Reference Books:

1. Klassen, C. 2017. Cassarett & Doull's Toxicology: The Basic Science of Poisons. McGraw-Hill.
2. Newman, M. C. and W. H. Clements, 2008: Ecotoxicology- A comprehensive treatment, CRC press.
3. Wright, D. A. and P. Welbourn, 2002. Environmental toxicology, Cambridge University press.
4. Willium P. L. and J. L. Burson, 1985. Industrial toxicology, safety and health applications in the workplace, Van Nostard Reinhold, New York.
5. Girard, J. E. 2015. Principles of Environmental chemistry. 3rd Ed. Jones & Barllett learning, New Delhi.
6. Walker, C. 2014. Ecotoxicology. CRC Press.
7. Jorgensen, SE. 2016. Ecotoxicology and Chemistry Applications in Environmental Management. CRC Press.
8. Lu F.C. & S Kacew 2002. Lu's Basic Toxicology. CRC Press.
9. Santra S. C. Environmental Science. New Central Book Agency.

Remote Sensing and Geographic Information System

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	VI
Course Title	Remote Sensing and Geographic Information System
Course Code	EVS11244
Credit	4
Contact Hours (L-T-P)	4-0-0
Course Type	DSE IV Theory
Course Objective	The objectives of this course are • To provide an understanding of the principles and concepts of remote sensing and Geographic Information Systems (GIS). • To introduce students to the different types of remote sensing data, including aerial and satellite imagery, and how to acquire and process them. • To teach students how to use GIS software to create, manage, Analyse, and visualize spatial data. • To explore the different applications of remote sensing and GIS in environmental monitoring, natural resource management, urban planning, and other fields. • To develop critical thinking and problem-solving skills by analyzing real-world environmental problems and using remote sensing and GIS tools to address them.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Develop a comprehensive understanding of the principles and concepts of remote sensing and Geographic Information Systems (GIS), and their role in environmental management and decision-making.

	CO2: Acquire and process different types of remote sensing data, including aerial and satellite imagery, and use GIS software to create, manage, Analyse, and visualize spatial data. **CO3:** Analyse and interpret remote sensing data, and apply spatial analysis techniques to identify patterns and relationships in environmental data. **CO4:** Evaluate the different applications of remote sensing and GIS in environmental monitoring, natural resource management, and urban planning, and their strengths and limitations. **CO5:** Develop critical thinking and problem-solving skills by analyzing real-world environmental problems and using remote sensing and GIS tools to address them.

Course Outline

Unit	Description
I	**Introduction to remote sensing:** Principles of Remote Sensing – History, Development of RS in India, Concept & Principles, Electromagnetic Radiation (EMR) and Its characteristics, Interaction of EMR with Atmosphere and Earth's Surface, Spectral Response and Spectral Signature, Spectral, Spatial, Temporal and Radiometric resolutions. Satellites and their Characteristics: Geo Synchronous and Sun Synchronous, Remote sensing systems, Platforms and their characteristics, Sensor classification: Active, Passive.
II	**Geographical Information Systems:** Introduction to GIS: 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.
III	**Data Structure:** GIS Data structure and format : Raster Data & its Representation: Data Structure, Data Compression, Raster file formats, Vector data representation: Data Structure, Comparison between Raster & Vector Data. Data Acquisition through Scanners and Digitizers, Methods of Digitization (Manual vs. Automated), Geometric Transformations of Raster and Vector Data, RMS Error, Sources of Errors in spatial data and, Spatial Data Quality: Accuracy, Precision, Error and Uncertainty. Data reception and data products: Data Formats, Ground segment organization, Pre-processing, Referencing Scheme, Data product generation, Data product output medium, Open Data Sources.
IV	**Applications and case studies :** Applications and case studies of remote sensing and GIS in geosciences, water resource management, land use planning, forest resources, agriculture, marine and atmospheric studies.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text and Reference Books:

1. Zar, J.H. 2010. Biostatistical Analysis (5th edition). Prentice Hall Publications.
2. Edmondson, A. & Druce, D.1996. Advanced Biology Statistics. Oxford University Press.
3. Demers, M.N. 2005. Fundamentals of Geographic Information System. Wiley & Sons.
4. Richards, J. A. & Jia, X. 1999. Remote Sensing and Digital Image Processing. Springer.
5. Sabins, F. F. 1996. Remote Sensing: Principles an Interpretation. W. H. Freeman.

Environmental Data Analysis

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	VI
Course Title	Environmental Data Analysis
Course Code	EVS11245
Credit	4
Contact Hours	4-0-0

(L-T-P)	
Course Type	DSE IV Theory
Course Objective	The objectives of this course are • To introduce students to statistical methods commonly used in environmental data analysis, including descriptive statistics, hypothesis testing, regression analysis, and time series analysis. • To provide students with hands-on experience in using statistical software packages to Analyse environmental data. • To teach students how to evaluate data quality and identify outliers and missing data. • To explore the different types of environmental data, including air and water quality data, weather data, and ecological data. • To develop critical thinking and problem-solving skills by applying statistical methods to real-world environmental problems.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Develop a solid understanding of statistical concepts and methods commonly used in environmental data analysis, including hypothesis testing, regression analysis, time series analysis, and spatial analysis. **CO2:** Acquire proficiency in using statistical software packages and programming languages to Analyse environmental data and produce informative visualizations. **CO3:** Learn how to evaluate data quality, identify outliers and missing data, and apply appropriate data cleaning and preprocessing techniques. **CO4:** Apply statistical methods to real-world environmental problems and develop critical thinking and problem-solving skills. **CO5:** Develop the ability to effectively communicate data analysis results and insights to different audiences, including scientists, policymakers, and the general public.

Course Outline

Unit	Description

I	**Introduction:** Data visualization, and distributions, Objectives, overview and organization, Visualizing distributions, Descriptive statistics, robust measures.
II	**2: Introduction to R:** What is R, Installation of R, A Few Important Syntax Conventions in R, Variables and Types, Data Structures, R Operators, Creating Subsets of a Matrix or Data Frame, Row or Column Operations on a Matrix or Data Frame Functions in R, Getting Data Into and Out of R, Plotting in R, Getting Help in R, Libraries and Packages, Tutorials for Learning R**.**
III	**Data screening and adjustments:** Summary statistics (e.g., means, standard deviations, quantiles), Missing data (e.g., single variable and multi-variable imputation), Frequency of occurrence and abundance plots, Dropping variables, Single variable distributions, Relationships between pairs of variables, Outliers, Data transformations, Data standardizations, Dissimilarity matrices.
IV	**Analysis of Environmental Data:** Deterministic functions, What is a deterministic (mathematical) function, Linear function – Example of local faunal species, Logistic function – Example of local faunal species, Ricker function , Bestiary of deterministic functions.
V	**Probability distributions:** What is a probability distribution, Plotting distributions, Bestiary of probability distributions, Classical tests:, Single sample, Two samples
VI	**Resampling procedures and stochastic simulations:** Bootstrap, Randomization tests, Stochastic simulations, Simulating static ecological processes, Simulating dynamic processes – population matrix mode

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text and Reference Books:

1. “Statistics for Environmental Science and Management” by Bryan F.J. Manly.
2. “Applied Statistics for Environmental Science with R” by Steven C. Hackett.
3. “Introduction to Environmental Statistics” by Ronald A. Fisher.
4. “Practical Statistics for Environmental and Biological Scientists” by John Townend.

5. “Environmental Statistics: Methods and Applications” by Vic Barnett and Ken Lewis.
6. “Environmental Data Analysis with Matlab” by William Menke.
7. “Data Analysis in Environmental Science” by R. Helmus and D. Faraway.
8. “Statistical Methods for Environmental and Agricultural Sciences” by Gilberto Antonelli and Marcelo J. Alonso.
9. “Environmental Statistics: Methods and Applications” by Vic Barnett and Ken Lewis.
10. “R Graphics for Environmental Science” by Richard Iannone.

Wastewater Engineering Lab

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	VI
Course Title	Wastewater Engineering Lab
Course Code	EVS12246
Credit	2
Contact Hours (L-T-P)	0-0-3
Course Type	DSE III Practical
Course Objective	The objectives of this course are • Understand the basic principles and concepts of wastewater engineering, including the physical, chemical, and biological processes involved in wastewater treatment. • Gain practical experience in designing and operating wastewater treatment systems, including physical, chemical, and biological treatment processes.

	• Learn how to use wastewater analysis techniques to assess the quality of wastewater and identify potential sources of pollutants. • Develop skills in evaluating and interpreting wastewater treatment data to optimize the performance of treatment systems. • Gain an understanding of the environmental, economic, and social aspects of wastewater management, and how they are integrated in the design and operation of • wastewater treatment systems. • Develop teamwork, communication, and problem-solving skills through hands-on laboratory exercises and group projects. • Practice good laboratory practices and safety protocols for handling and analyzing wastewater samples.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Demonstrate an understanding of the principles and processes involved in the design and operation of wastewater treatment systems. **CO2:** Apply laboratory techniques to Analyse and evaluate wastewater treatment data, and interpret results to optimize treatment processes. **CO3:** Collaborate with peers in group projects and case studies, and communicate effectively in written and oral formats to present findings and recommendations. **CO4:** Identify and assess environmental, economic, and social factors that influence wastewater management decisions, and develop solutions that are sustainable and socially responsible. **CO5:** Implement laboratory safety protocols and best practices for handling and analyzing wastewater samples, and demonstrate a commitment to maintaining a safe and ethical laboratory environment.

Course Outline

Unit	Description
I	1. Sampling and analysis of Industrial wastewater. 2. Sampling and analysis of surface water. 3. Designing a wastewater treatment plant 4. Determination of iron 5. Determination of sodium content 6. Determination of potassium content

	7. Determination of nitrates 8. Determination of optimum dosage of coagulant 9. Determination of quantity of residual chlorine

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Environmental Health and Toxicology Lab

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	VI
Course Title	Environmental Health and Toxicology Lab
Course Code	EVS12247
Credit	2
Contact Hours (L-T-P)	0-0-3
Course Type	DSE III Practical
Course Objective	The objectives of this course are • To introduce students to the basic principles and methods of environmental health and toxicology. • To provide students with hands-on experience in conducting experiments and analyzing data related to environmental health and toxicology.

	• To familiarize students with common environmental health and toxicology laboratory techniques and equipment. • To teach students how to identify and assess environmental hazards, and to evaluate the risks associated with exposure to environmental toxins. • To enable students to apply scientific reasoning and critical thinking skills to environmental health and toxicology problems. • To promote effective communication and collaboration among students, and to encourage teamwork and problem-solving skills. • To foster an appreciation for the importance of environmental health and toxicology research and its impact on public health and the environment. • To provide students with a foundation for further study or careers in environmental health and toxicology, as well as related fields such as public health, toxicology, environmental science, and environmental policy.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Develop proficiency in conducting laboratory experiments related to environmental health and toxicology, using appropriate techniques and equipment. **CO2:** Analyse and interpret data collected from laboratory experiments, and use this data to draw evidence-based conclusions about environmental health and toxicology issues. **CO3:** Apply scientific principles to evaluate and assess environmental hazards and risks, including exposure to toxins, and develop strategies to minimize these risks. **CO4:** Demonstrate effective communication skills in presenting laboratory findings and analysis, both orally and in writing, to diverse audiences. **CO5:** Understand the ethical implications of environmental health and toxicology research, including the need to protect human and animal subjects, and apply ethical principles in laboratory and research activities.

Course Outline

Unit	Description
I	1. Dose- Response Relationship; Whole Effluent Toxicity (WET) test; Bioassay - types, methodologies and application.

	2. Methods on Basic analytical toxicology.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Remote Sensing and Geographic Information System Lab

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	VI
Course Title	Remote Sensing and Geographic Information System Lab
Course Code	EVS12248
Credit	2
Contact Hours (L-T-P)	0-0-3
Course Type	DSE IV Practical
Course Objective	The objectives of this course are • To provide students with hands-on experience in using remote sensing and GIS software and tools for data analysis and visualization.

	• To teach students how to collect, process, and interpret remotely sensed data and spatial data, such as satellite images, aerial photographs, and digital elevation models. • To enable students to apply remote sensing and GIS techniques to solve real-world problems related to environmental monitoring, land use planning, natural resource management, and urban planning. • To promote effective communication and collaboration among students, and to encourage teamwork and problem-solving skills. • To foster an appreciation for the importance of remote sensing and GIS in various fields, such as environmental science, geography, geology, urban planning, and natural resource management. • To provide students with a foundation for further study or careers in remote sensing and GIS, as well as related fields such as geospatial technology, cartography, and surveying. • To develop critical thinking and spatial analysis skills among the students.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Develop proficiency in using remote sensing and GIS software and tools for data acquisition, processing, analysis, and visualization. **CO2:** Apply remote sensing and GIS techniques to solve real-world problems related to environmental monitoring, land use planning, natural resource management, and urban planning. **CO3:** Analyse and interpret remotely sensed data and spatial data using appropriate methods and tools, and draw evidence-based conclusions about spatial relationships and patterns. **CO4:** Demonstrate effective communication skills in presenting remote sensing and GIS findings and analysis, both orally and in writing, to diverse audiences. **CO5:** Understand the ethical implications of remote sensing and GIS research, including issues related to data privacy, intellectual property, and environmental and social justice, and apply ethical principles in laboratory and research activities.

Course Outline

Unit	Description

I	Familiarization with the various remote sensing software, downloading satellite data from various sources in the world wide web, displaying satellite image in different colour composites, Field Spectra Collection: vegetation, bare soil, and concrete using Spectro Radiometer and analyse it with satellite data, Extraction of Water bodies and Agricultural land use from a given satellite image, Discriminate Land surface features using spectral, thermal and microwave satellite images.
II	Familiarization with the GIS software, Georeferencing of spatial data in GIS software, Geodatabase creation and Digitization of point line and polygon features, Creation of Spatial data from Non-spatial data, Topology creation of spatial data, Removing topological error, Attribute data Integration with spatial data, Map Designing (layout creation), Thematic Map creation, Performing vector analysis; Attribute query, buffering, overlay.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Environmental Data Analysis Lab

School	School of Basic and Applied Sciences
Programme/Discipline	B.Sc. (H)
Batch	2022-23
Semester	VI
Course Title	Environmental Data Analysis Lab
Course Code	EVS12248
Credit	2
Contact Hours (L-T-P)	0-0-3

Course Type	DSE IV Practical
Course Objective	The objectives of this course are • To introduce students to the basic principles and methods of environmental data analysis, including statistical analysis, data visualization, and data interpretation. • To provide students with hands-on experience in using software and tools for data analysis, such as R, MATLAB, or Python. • To teach students how to collect, manage, and preprocess environmental data, such as climate data, water quality data, or air quality data, and how to perform quality control and assurance on this data. • To enable students to apply statistical and data analysis techniques to solve real-world environmental problems, such as pollution monitoring, climate change analysis, or ecological modeling. • To promote effective communication and collaboration among students, and to encourage teamwork and problem-solving skills. • To foster an appreciation for the importance of data analysis in various fields of environmental science, such as ecology, hydrology, atmospheric science, and environmental health. • To provide students with a foundation for further study or careers in environmental data analysis, as well as related fields such as data science, statistics, or environmental informatics. • To develop critical thinking and problem-solving skills among the students, and to encourage them to think creatively and independently when approaching environmental data analysis problems.
Course Outcome (CO)	After completion of this course, students will be able to: **CO1**: Develop proficiency in using statistical software and tools, such as R, MATLAB, or Python, for environmental data analysis, and apply these skills to real-world environmental problems. **CO2:** Understand the principles of data management, quality control and assurance, and data preprocessing, and apply these principles to ensure the accuracy and validity of environmental data.

	CO3: Analyse and interpret environmental data using appropriate statistical methods and tools, and draw evidence-based conclusions about environmental processes and phenomena. **CO4:** Communicate environmental data analysis findings and results effectively, both orally and in writing, to diverse audiences, and demonstrate effective teamwork and collaboration skills. **CO5:** Understand the ethical and social implications of environmental data analysis, including issues related to data privacy, data ownership, and environmental and social justice, and apply ethical principles in laboratory and research activities.

Course Outline

Unit	Description
I	**Major pollutants in the Ganga River** 1. major ions in local precipitation and surface water. 2. how does an ion chromatograph work? 3. standards and error bars 4. calibration curves 5. how to write a lab report
II	**Particulate matter in Kolkata** 1. atmospheric chemistry of ozone 2. basics in Excel, data entry 3. atmospheric transport in NYC area, average, standard deviation, median 4. evaluation of ozone data of a particular day for everybody 5. basic statistics (histogram, mean, SD), lab report format 6. evaluation of extended ozone data set 7. how to conduct an experiment 8. particulate matter in air 9. evaluation of particulate matter experiment 10. advanced statistics: normal distributions, significance tests (t-tests) 11. statistical analysis of data, determination of fluxes, discussion of p.m. sources
III	**Bathymetry and sediment distribution in the Ganga River off Kolkata** 1. Overview of GIS systems and applications 2. Coordinate systems and projections 3. Spatial data formats and editing spatial data 4. Working with attribute tables in a GIS 5. Basic spatial analysis 6. Making maps with ArcGIS

	7. Using GIS to Analyse the Bathymetry and sediment distribution in the Hudson River 8. GIS on the Internet

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%