SYLLABI AND SCHEME OF EXAMINATION

For

M.Sc. (ENVIRONMENTAL SCIENCE)

(Based on Curriculum and Credit Framework for PG Programs under NEP)

MAHARSHI DAYANAND UNIVERSITY
ROHTAK (HARYANA)

Structure for 2-year Post Graduate Programme

	Semester	Discipline-Specific Courses (DSC)	Skill Enhancement Courses (SEC) / Vocational Courses (VOC)/ Internship	Research thesis/project	Total Credits
	First year of 2 Year PG program (NHEQF Level 6)				
	I	DSC 1 Environmental Biology @ 4 credits DSC 2 Analytical Techniques @ 4 credits DSC 3 Environmental Pollution @ 4 credits DSC 4 Environmental Toxicology @ 4 credits DSC 5 Solid Waste Management@ 4 credits	SEC1 Techniques in Environmental Monitoring-I @ 4 credits	---	24
	II	DSC 6 Natural Resources @ 4 credits DSC 7 Biodiversity @ 4 credits DSC 8 Biostatistics & Environmental Modelling @ 4 credits DSC 9 Resource Management @ 4 credits DSC 10 Waste water Treatment Technology@ 4 credits	SEC2 Techniques in Environmental Monitoring- II @ 4 credits	---	24
Students who exit after first year on completion of 48 credits will be awarded PG Diploma in concerned discipline					
Second year of two year PG program (NHEQF Level 6.5) (STUDENT SHOULD SELECT ANY ONE OPTION FOR THE SECOND YEAR OF 2 YEAR PG PROGRAM)					
Only Course Work					
Option 1	III	DSC 11 Environmental Chemistry @ 4 credits DSC 12 Elementary Concept of Physical Environment @ 4 credits DSC 13 Environmental Impact Assessment @ 4 credits DSC 14 Remote Sensing and Geological Information Technology @ 4 credits DSC 15 Environmental Microbiology @ 4 credits	SEC 3 Techniques in Environmental Monitoring- III @ 4 credits	---	24
	IV	DSC 16 Environmental Laws @ 4 credits DSC17 Environmental Management & Planning @ 4 credits	SEC 4 Environmental Data Handling and Statistics/ *Internship @ 4 credits		24

		DSC18 Environmental Geology @ 4 credits DSC18 Academic Writing @ 4 credits DSC20 Climate Change and Sustainability @ 4 credits			
Course work and Research (Only for students securing ≥75% in first year)					
Option 2	III	DSC 11 Environmental Chemistry @ 4 credits DSC 12 Elementary Concept of Physical Environment @ 4 credits DSC 13 Environmental Impact Assessment @ 4 credits DSC 14 Remote Sensing and Geological Information Technology @ 4 credits DSC 15 Environmental Microbiology @ 4 credits	SEC 3 Techniques in Environmental Monitoring- III @ 4 credits	---	24
	IV	--	SEC 4 Environmental Data Handling and Statistics/ *Internship @ 4 credits	Research thesis/project @20 credits	24

Only Research (only for the students who have completed 3 Years Bachelor's Program)					
	Semester	Discipline-Specific Courses (DSC)	Skill Enhancement Courses (SEC) / Vocational Courses (VOC)/ Internship	Research thesis/project	Total Credits
Option 3**	III	--	SEC 3/*Internship 3 @ 4 credits	20 credits*	24
	IV	--	SEC 4/*Internship 4 @ 4 credits	20 credits**	24

Note:

*The students are required to submit a comprehensive report highlighting their learning and takeaways during the internship period duly signed by Internship supervisor from UTD and mentor from internship providing organization. The evaluation of the internship report and viva-voce will be jointly conducted by the Internship supervisor and mentor from internship providing organization. There will be assessment of 30 marks by the mentor, internship report of 40 marks and Viva voce of 30 marks comprising a total of 100 marks.

** The students who opted Option 3 should submit a project report/synopsis comprising of Literature survey, identification of Research Problem, Plan of work, methodology as well as practical work (if any) at the end of 3rd semester and the same will be evaluated by internal and external examiners.

**The students should continue the research work in 4th semester based on the project work/synopsis submitted at the end of 3rd semester. The final thesis/project report will be evaluated by the internal and external examiners.

Structure for 1 year Post Graduate Programme (2nd year of 2 Year PG Program)

	Semester	Discipline Specific Courses (DSC)	Skill Enhancement Courses (SEC) / Vocational Courses (VOC)/Internship	Dissertation/ Project work	Total Credits
(STUDENT SHOULD SELECT ANY ONE OPTION)					
Only Course Work					
Option 1	I (Semester III of 2 year PG Program)	DSC 11 Environmental Chemistry @ 4 credits DSC 12 Elementary Concept of Physical Environment @ 4 credits DSC 13 Environmental Impact Assessment @ 4 credits DSC 14 Remote Sensing and Geological Information Technology @ 4 credits DSC 15 Environmental Microbiology @ 4 credits	SEC 3 Techniques in Environmental Monitoring- III @ 4 credits	---	24
	II (Semester IV of 2 year PG Program)	DSC 16 Environmental Laws @ 4 credits DSC17 Environmental Management & Planning @ 4 credits DSC18 Environmental Geology @ 4 credits DSC19 Academic Writing @ 4 credits DSC20 Climate Change and Sustainability @ 4 credits	SEC 4 Environmental Data Handling and Statistics/ *Internship @ 4 credits	---	24
Course work and Research					
Option 2	I (Semester III of 2 year PG Program)	DSC 11 Environmental Chemistry @ 4 credits DSC 12 Elementary Concept of Physical Environment @ 4 credits DSC 13 Environmental Impact Assessment @ 4 credits DSC 14 Remote Sensing and Geological Information Technology @ 4 credits DSC 15 Environmental Microbiology @ 4 credits	SEC 3 Techniques in Environmental Monitoring- III @ 4 credits	---	24
	II (Semester IV of 2 year PG Program)		SEC 4 Environmental Data Handling and Statistics/ *Internship @ 4 credits	Dissertation/ Project work @ 20 credits	24

SCHEME OF EXAMINATION FOR POST GRADUATE PROGRAM IN ENVIRONMENTAL SCIENCE

Type of Course	Nomenclature of Course	Course Code	Credits Distribution			Total Credits	Workload			Total Workload	Marks			Total Marks
			L	T	P		L	T	P		Theory		Practical	
											Internal	External		
Semester I														
DSC 1 @ 4 credits	Environmental Biology	24EVS201DS01	4	0	0	4	4	0	0	4	30	70	-	100
DSC 2 @ 4 credits	Analytical Techniques	24EVS201DS02	4	0	0	4	4	0	0	4	30	70	-	100
DSC 3 @ 4 credits	Environmental Pollution	24EVS201DS03	4	0	0	4	4	0	0	4	30	70	-	100
DSC 4 @ 4 credits	Environmental Toxicology	24EVS201DS04	4	0	0	4	4	0	0	4	30	70	-	100
DSC 5 @ 4 credits	Solid waste Management	24EVS201DS05	4	0	0	4	4	0	0	4	30	70	-	100
SEC1 1 @ 4 credits	Techniques in Environmental Monitoring –I	24EVS201SE01	0	0	4	4	0	0	8	8	-	-	100	100
Semester II														
DSC 6 @ 4 credits	Natural Resources	24EVS202DS01	4	0	0	4	4	0	0	4	30	70		100
DSC 7 @ 4 credits	Biodiversity	24EVS202DS02	4	0	0	4	4	0	0	4	30	70	-	100
DSC 8 @ 4 credits	Biostatistics & Environmental Modelling	24EVS202DS03	4	0	0	4	4	0	0	4	30	70	-	100
DSC 9 @ 4 credits	Resource Management	24EVS202DS04	4	0	0	4	4	0	0	4	30	70	-	100
DSC 10 @ 4 credits	Waste Water Treatment Technology	24EVS202DS05	4	0	0	4	4	0	0	4	30	70	-	100
SEC2 @ 4 credits	Techniques in Environmental Monitoring-II	24EVS202SE01	0	0	4	4	0	0	8	8	-	-	100	100

Type of Course	Nomenclature of Course	Course Code	Credits Distribution			Total Credits	Workload			Total Workload	Marks			
			L	T	P		L	T	P		Theory		Practical	Total Marks
											Internal	External		
Semester III														
DSC 11 @ 4 credits	Environmental Chemistry	25EVS203DS01	4	0	0	4	4	0	0	4	30	70	-	100
DSC 12 @ 4 credits	Elementary concept of Physical Environment	25EVS203DS02	4	0	0	4	4	0	0	4	30	70	-	100
DSC 13 @ 4 credits	Environmental Impact Assessment	25EVS203DS03	4	0	0	4	4	0	0	4	30	70	-	100
DSC 14 @ 4 credits	Remote sensing and Geological Information technology	25EVS203DS04	4	0	0	4	4	0	0	4	30	70	-	100
DSC 15 @ 4 credits	Environmental Microbiology	25EVS203DS05	4	0	0	4	4	0	0	4	30	70	-	100
SEC 3 @ 4 credits	Techniques in Environmental Monitoring III	25EVS203SE01	0	0	4	4	0	0	8	8	-	-	100	100
Semester IV OPTION 1														
DSC 16 @ 4 credits	Environmental Laws	25EVS204DS01	4	0	0	4	4	0	0	4	30	70	-	100
DSC 17 @ 4 credits	Environmental Management& Planning	25EVS204DS02	4	0	0	4	4	0	0	4	30	70	-	100
DSC18 @ 4 credits	Environmental Geology	25EVS204DS03	4	0	0	4	4	0	0	4	30	70	-	100
DSC19 @ 4 credits	Academic Writing	25EVS204DS04	4	0	0	4	4	0	0	4	30	70	-	100
DSC20 @ 4 credits	Climate Change and Sustainability	25EVS204DS05	4	0	0	4	4	0	0	4	30	70	-	100
SEC4/Internship 4/ @ 4 credits	Environmental Data Handling and Statistics /Internship	25EVS204SE01 25EVS204IN01	0	0	4	4	0	0	8	8	-	-	100	100

Semester IV OPTION 2														
SEC4/ Internship 4 @ 4 credits	Environmental Data Handling and Statistics /Internship	25EVS204SE01 25EVS204IN01	0	0	4	4	-	-	-	8	-	-	100	100
Research thesis/ project @20 credits	Dissertation/Project work	25EVS204PD01	0	0	20	20	-	-	40	40	-	-	500	500

Semester III OPTION 3														
SEC3/ Internship 4 @ 4 credits	Techniques in Environmental Monitoring III /Internship	25EVS203SE01 25EVS203IN01	0	0	4	4	-	-	-	8	-	-	100	100
Research thesis/ project @20 credits	Dissertation/Project work	25EVS203PD01	0	0	20	20	-	-	40	40	-	-	500	500
Semester IV OPTION 3														
SEC4/ Internship 4 @ 4 credits	Environmental Data Handling and Statistics /Internship	25EVS204SE01 25EVS204IN01	0	0	4	4	-	-	-	8	-	-	100	100
Research thesis/ project @20 credits	Dissertation/Project work	25EVS204PD01	0	0	20	20	-	-	40	40	-	-	500	500

L: Lecture; T: Tutorial; P: Practical

Syllabi for Post Graduate Program in Environmental Science

Semester - I

Name of Program	**M.Sc. Environmental Science**	**Program Code**	**ENV2**
Name of the Course	**Environmental Biology**	**Course Code**	**24EVS201DS01**
Hours per Week	**4**	**Credits**	**4**
Maximum Marks	**70**	**Time of Examination**	**3 hours**

Note: Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1: Students would be able to understand the vital connections between plants, animals and the world around them.

CLO 2: Students would learn principle, scope of ecology and ecosystem stability along with its regulation.

CLO 3: Students would be able to analyse the roles of organisms as part of interconnected food webs, populations, communities and ecosystems.

CLO 4: Students would get sufficient knowledge and understand the significance of competition, Predation, dispersal, mortality and survival strategies for changes and fluctuations in population sizes.

Unit 1: Definition, principles and scope of ecology, human ecology and human settlements, evolution, origin of life and speciation, Ecosystem stability-cybernetics and ecosystem regulation, evolution of biosphere.

Unit 2: Ecosystem structure and functions, abiotic and biotic component, Energy flow, food chain, food web, Ecological Pyramids-types, biogeochemical cycles, ecological succession, Ecads and ecotypes.

Unit 3: Population ecology- density, natality, mortality, survivorship curves, age distribution, growth curves and models, r &k selection, population interactions- Mutualism, Parasitism, Predator- Prey relations, System Theory and Ecological Model.

Unit 4: Earths major ecosystem - terrestrial and aquatic ecosystem, soil microorganism and their functions, coastal management, criteria employed for disposal of pollutants in marine ecosystem, coastal water system and man-made reservoirs, biology and ecology of reservoirs.

Suggested readings:

1. Odum, E.P. (1983). Basic ecology, Holt-Saunders (Japan)
2. Smith R.L. (1966). Ecology and field biology, Harper & Row
3. Sharma, P.D. (2000). Ecology & Environment, 7th Edition, Rastogi Publications, Meerut.
4. Odum, E.P. (2005). Fundamentals of Ecology, 5th Edition, Cengage Learning Publication.
5. Rickleff (2008). Principles of ecology, W.H. Freeman and Company.
6. J.S. Singh, S.P. Singh and S.R. Gupta. (2008). Ecology, Environment & Resource Conservation. Anamaya Publications.
7. Begon, M., Townsend, C.R. and Herper, J.L. (2005). Ecology: From Individuals to Ecosystems, 4th Edition, John Wiley & Sons
8. Cunningham, W. P. and Cunningham, M. A. (2004). Principles of Environment Science. Enquiry and Applications. 2nd Edition. Tata McGraw Hill, New Delhi
9. Smith, T.M. and Smith, R.L. (2015). Elements of Ecology. 9th Edition, Pearson Benjamin Cummings, USA

Name of Program	M.Sc. Environmental Science	Program Code	ENV2
Name of the Course	Analytical Techniques	Course Code	24EVS201DS02
Hours per Week	4	Credits	4
Maximum Marks	70	Time of Examination	3 hours

Note: Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1: Understand the design, operational principles and practical applications of modern instrumental methods employed in chemical analysis of environmental samples.
CLO 2: Explain the concept of spectrometry and optical techniques.
CLO 3: Elucidate the working of chromatography, elemental analyser and electrophoresis.
CLO 4: Illustrate the working of X- ray diffractometer and scanning electron microscope.
CLO 5: Explain the techniques used for analysis based on DNA and proteins biomolecules.

Unit 1: Principles and application of Spectrophotometry (UV-Visible spectrophotometry), Titrimetry, Gravimetry, Colorimetric, NMR, ESR, Microscopy-phase, light and fluorescence microscopes, Scanning and Transmission electron microscopes.

Unit 2: Chromatographic techniques (Paper chromatography, thin layer chromatography, ion exchange chromatography, Column chromatography), Atomic absorption spectrophotometry, cytophotometry and flow cytometry, Fixation and staining, Principles and techniques of nucleic acid hybridization and Cot curves, Plasma emission spectroscopy.

Unit 3: Electrophoresis, solid and liquid scintillation, X-ray florescence, X-ray diffraction. Flame photometry, Gas-liquid chromatography, High pressure liquid chromatography – autoradiography, Ultracentrifugation.

Unit 4: Methods for measuring nucleic acid and protein interactions, DNA finger printing Molecular markers RFLP, AFLP, RAPD, Sequencing of proteins and nucleic acids, southern, northern, western blotting techniques, PCR polymerase chain reaction.

Suggested readings:

1. Avinash Upadhyay, Kakoli Upadhyay, Nirmalendu Nath (2009) Biophysical chemistry: Principles and techniques, Himalaya Publication House.
2. David Freifelder (1976) Physical Biochemistry: Applications to Biochemistry and Molecular Biology, W. H. Freeman and Company, San Francisco.
3. Sambrook and Russell (2007) Molecular cloning A Laboratory Manual 3rd edition Vol. 1, 2, 3, Cold Spring Harbor Laboratory Press.
4. Keith Wilson and John Walker (Eds.) (2010) Principals and Techniques of Biochemistry and Molecular Biology, Edited by, 7th Edition, Cambridge University Press.
5. Rajan Katoch (2011) Analytical Techniques in Biochemistry and Molecular Biology, Springer-Verlag New York.

Name of Program	**M.Sc. Environmental Science**	**Program Code**	**ENV2**
Name of the Course	**Environmental Pollution**	**Course Code**	**24EVS201DS03**
Hours per Week	**4**	**Credits**	**4**
Maximum Marks	**70**	**Time of Examination**	**3 hours**

Note: Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1: Students would come to know the air pollution, their sources and behaviour of pollutants in the atmosphere and methods for monitoring air pollution.

CLO 2: Students would study about the water pollution including sources and its consequences. They will learn about how to analyse the water quality and the treatment of wastewater.

CLO 3: Students would know about soil pollution, analysis of soil quality control of soil pollution and the interaction of these pollutants with soil components.

CLO 4: Students would get the sufficient knowledge regarding noise pollution and marine pollution, their sources and control.

Unit 1: Air pollution- natural and anthropogenic sources of pollution, primary and, transport and diffusion of pollutants, gas laws governing the behaviour of pollutants in the atmosphere, Methods of monitoring and control of air pollution, SO_2, NOx, CO, SPM.

Unit 2: Water pollution - types sources and consequences of water pollution, physic-o-chemical and bacteriological sampling, Analysis of water quality, standards, sewage and wastewater treatment and recycling, water quality and standards.

Unit 3: Soil pollution chemical and bacteriological sampling as analysis of soil quality, soil pollution control, industrial waste effluents and heavy metals and their interactions with soil components.

Unit 4: Noise pollution - sources of noise pollution, measurement and indices, Marine pollution, sources of marine pollution and its control, Effects of pollutants on human beings, plants, animals and climate, air quality standards and air pollution.

Suggested readings:

1. Krishan, K.V.S.G.M. (2015) Air pollution and control. University Science Press.
2. Bell, L.H. and Bell, D.H. (1993) Industrial Noise Control. CRC Press
3. Rao, C.S. (2006) Environmental Pollution Control Engineering. New Age International.
4. Rao, M. and Rao, H.V.N. (2017) Air Pollution. McGraw Hill Education.
5. Gilbert, M. M. and Ela, W.P. (2007) Introduction to Environmental Engineering and Science. Pearson.

Name of Program	M.Sc. Environmental Science	Program Code	ENV2
Name of the Course	Environmental Toxicology	Course Code	24EVS201DS04
Hours per Week	4	Credits	4
Maximum Marks	70	Time of Examination	3 hours

Note: Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1: Students would get awareness about toxicity of chemicals in Environment.
CLO 2: Students will understand about toxic substances & xenobiotics and their mode of entry into human beings.
CLO 3: Students would understand about the possible imbalance of major and trace elements in human beings.
CLO 4: Students would know about biogeochemical factors and effect on environmental health.
CLO 5: Students will be able to apply the knowledge in the context of the environmental quality, public health and sustainability.

Unit 1: Toxic chemicals in the environment - air, water & their effects. Pesticides in water. Bio-chemicals aspects of arsenic, cadmium, lead mercury, carbon monoxide, ozone and PAN, pesticide.

Unit 2: Mode of entry of toxic substance, Process of biotransformation of xenobiotics, Carcinogens in air, chemical carcinogenicity, mechanism of carcinogenicity, Environmental carcinogenicity testing.

Unit 3: Insecticides, MIC effects, Concept of major, trace and Rare Earth Element (REE)-possible effects of imbalance of some trace elements and human health, classification of trace elements, Mobility of trace elements.

Unit 4: Biogeochemical factors in environmental health, Epidemiological issue- goitre, fluorosis, arsenic poisoning, Diseases induced by human use of land.

Suggested readings:

1. Casarett and Doull's (1991). Toxicology (4th Ed). Pergamon Press, Inc.
2. Zakrzewksi, S. F. (1991). Principles of Environmental Toxicology. American Chemical Society.
3. Richards, I. S. (2008). Principles and Practice of Toxicology in Public Health. Jones and Bartlett Publishers, Inc.
4. Cockerham, L. G. and Shane, B. S. (1994). Basic Environmental Toxicology. CRC Press.
5. Gupta, P.K. (2016). Fundamentals of Toxicology: Essential Concepts and Applications. Academic Press.

Name of Program	M.Sc. Environmental Science	Program Code	ENV2
Name of the Course	Solid Waste Management	Course Code	24EVS201DS05
Hours per Week	4	Credits	4
Maximum Marks	70	Time of Examination	3 hours

Note: Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1: By analysis students would get the practical knowledge about waste characteristic and their effects.
CLO 2: Students would be able to analyze the physicochemical parameters like calorific value, different cations and anions present in the solid waste as compared to the soil.
CLO 3: Students will get the knowledge about sanitary landfill site its operation and beneficial effect.
CLO 4: Students would be able to understand waste water treatment and recycling methods.

Unit – 1: Sources, generation, classfication & composition of solid wastes. Solid waste management methods - Sanitary land filling, Composting, Vermi composting, incineration and burial, energy recovery from organic waste.

Unit -2: Solid Waste Management Plan, Waste minimization technologies, Hazardous Waste Management, Sources & Classification, physicochemical properties, Hazardous Waste Control & Treatment.

Unit -3: Hospital Waste Management. Hazardous Waste Management & Handling rules, 1989 & 2000 (amendments), Recycling of waste materials, Garbage gravel yards.

Unit- 4: Disaster Management and Risk analysis, Fly ash generation & utilization, Primary, secondary & tertiary & advance treatment of various effluents, Beverage container deposit bill.

Suggested readings:

1. Landrefh, R.E. and Rebers, P.A. (1997). Municipal Solid Wastes-Problems & Solutions. Lewis Publication
2. Pichtel J. (2005). Waste Management Practices. CRC Press,Taylor and Francis Group.
3. Datta, M. (1997). Waste Disposal in Engineered Land fill. Narosa Publishers, Delhi.
4. Gupta O.P. (2018). Elements of Solid Hazardous Waste and Management. Khanna Publishing House.
5. Sharma, H. and Reddy, K (2004). Geoenvironmental Engineering: Site Remediation, Waste Containment, and Emerging Waste Management Technologies. Wiley Publisher.

Name of Program	M.Sc. Environmental Science	Program Code	ENV2
Name of the Course	Techniques in Environmental Monitoring –I	Course Code	24EVS201SE01
Hours per Week	8	Credits	4
Maximum Marks	100		

Note: The practical exam of Techniques in Environmental Monitoring –I will be conducted at the end of semester. The question paper of practical will be prepared by external examiner, total marks of exam will be100.

Course Learning Outcomes (CLO):

CLO 1: Students would able to monitor the pollution.
CLO 2: Students would able to measure the physic-chemical properties of soil.
CLO 3: Students would able to estimate distribution pattern of a community in the particular area.
CLO 4: Students would get the sufficient knowledge to measure photosynthetic pigments.

Experiments

1. To study soil profile of a given area.
2. To determine the organic carbon in the soil sample.
3. To determine the calcium and magnesium in the soil samples.
4. To determine moisture content, water holding capacity, pH and conductivity of the soil samples.
5. To determine the distribution pattern of a plant community.
6. To determine the basal area and dominance of different species in a particular vegetation area.
7. To determine Important Value Index of a given vegetation area.
8. To verify Beer- Lambert's Law of absorption of light.
9. To study absorption spectrum of bromophenol blue as indicator dye at different pH range.
10. To perform paper chromatography of amino acids and calculation of Rf value.
11. Isolation of plant pigments by column chromatography and study their absorption spectrum.
12. To perform agarose gel electrophoresis for separation of nucleic acids.
13. To study effect of different antibiotics on growth of bacteria and calculation of their EC50.
14. To study effects of pesticides on the insects and determination of LD50.
15. To study the effect of industrial effluent on germination of seeds.
16. To determine the physical and chemical properties of solid waste in comparison to soil.
17. To determine the calorific value of solid waste using bomb calorimeter.
18. To estimate the ammonia in given solid waste sample.
19. To visit industry to learn about effluent treatment plant (ETP).
20. To prepare report on hospital waste management of the city.
21. Analysis of Fly ash physic-o-chemical properties.
22. To study the recycling of waste materials like e-waste, plastic waste, paper waste..

Semester-II

Name of Program	**M.Sc. Environmental Science**	**Program Code**	**ENV2**
Name of the Course	**Natural Resources**	**Course Code**	**24EVS202DS01**
Hours per Week	**4**	**Credits**	**4**
Maximum Marks	**70**	**Time of Examination**	**3 hours**

Note: Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1: Students would gain an understanding of the need for using non-renewable sources of energy.
CLO 2: Students would get sufficient exposure of solar energy and fossil fuels classification, composition and their characteristics.
CLO 3: Students would learn about various renewable energy sources and carbon credits.
CLO 4: Students would understand the global energy pattern and impacts of exploitation of renewable energy sources

Unit 1: Sun as a source of energy, solar radiations and its spectral characteristics fossil fuels classification, composition, physic-o- chemical characteristics and energy content of coal, petroleum and Natural gas.

Unit 2: Principles of generation of hydroelectric power, tidal power, thermal energy conversion, wind, geo thermal energy, solar collectors, photovoltaic, solar ponds, oceans, Soil microorganisms and their functions, Carbon credits

Unit 3: Nuclear energy- fission and fusion, bio energy -energy from biomass and biogas, anaerobic digestion, energy use patterns in different parts of the world. Impacts of large scale exploitation of solar, wind, hydro and ocean energy.

Unit 4: Mineral resources and reserves, ocean ores and recycling of resources, Environmental impact of exploitation, processing and smelting of Mineral, oceans as need areas for exploitation of Mineral resources.

Suggested readings:

1. T.J. Miller. (2003) Living in the environmental, 5th edition, Brooks/Cole
2. Owen & Chiras (1990), Natural resource conservation, 5th edition, Macmillan USA
3. Encyclopedia of Energy - I & II. (2008), First Edition, Elsevier
4. Craig, J.R., Vaughan, D.J. Skinner, B.J. (1996). Resources of the Earth: Origin, Use, And Environmental Impact, (2nd Ed). Prentice Hall, New Jersey
5. Owen, O.S, Chiras, D.D. & Reganold, J.P. (1998). Natural Resource Conservation – Management For Sustainable Future, (7thEdn.), Prentice Hall.
6. Twidell, I.J. and Tony, W. (2007). Renewable Energy Resources. Taylor and Francis Group.
7. Vaughn Nelson. (2011). Introduction to Renewable Energy. CRC Press

Name of Program	M.Sc. Environmental Science	Program Code	ENV2
Name of the Course	Biodiversity	Course Code	24EVS202DS02
Hours per Week	4	Credits	4
Maximum Marks	70	Time of Examination	3 hours

Note: Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1: Student would learn the global biodiversity crisis and would be able to articulate why society strives to conserve biodiversity.

CLO 2: Students would be able to identify key threats to biodiversity and learn the management options for conserving biodiversity.

CLO 3: Students would be able to develop and analyse appropriate biodiversity conservation policy for conserving biodiversity across a range of mediums.

CLO 4: The students would be able to argue the case for local action to address the global loss of biodiversity and conserving biodiversity.

Unit 1: Biodiversity - definition, hot spots of Biodiversity, strategies for Biodiversity Conservation, National Parks, Sanctuaries and Biosphere reserves, gene pool, Sustainable development, Habitat.

Unit 2: Aquatic common flora and fauna in India - phytoplankton, zooplankton and macrophytes, terrestrial common flora and fauna in India - forests, endangered and threatened species.

Unit 3: Strategies for Biodiversity Conservation, cryopreservation, gene banks, tissue culture and artificial seed technology, new seed development policy 1988, conservation of medicinal plants.

Unit 4: International conventions, treaties and protocols for Biodiversity Conservation, Biodiversity in the welfare of mankind, Species concept, Biological nomenclature theories of biological classification.

Suggested readings:

1. Botkin, Daniel B. and Keller, Edward A. 2007 Environmental Science: Earth as a Living Planet. 6th ed. John Wiley & Sons, USA.
2. Enger, E.D. and Smith, B. F. 2006 Environmental Science: A Study of Interrelationships. 11th ed. McGraw Hill Inc., USA.
3. Frankel, O.H., Brown A.H.D. and Burdon, J.J. 1995 Conservation of Plant Biodiversity. Cambridge University Press, UK.
4. Gaston, K. J. and Spicer, J. I. 1998 Biodiversity: An Introduction. Blackwell, UK.
5. Gadgil, Madhav and Rao, P.R.S. 1999 Nurturing Biodiversity: An Indian Agenda. Centre or Environment Education, Ahmedabad, India..
6. Hunter, Malcolm L., Jr., and Gibbs, James P. 2006. Fundamentals of Conservation Biology. 3rd ed. Wiley-Blackwell.
7. Jeffries, M. 1997. Biodiversity and Conservation. 2nd ed. Routledge, UK.
8. Perrings, Charles, Maler, Karl-Goran, Folke, Carl, Holling, C. S. and Jansson, Bengt-Owe. 1997. Biodiversity Loss: Economic and Ecological Issues. Cambridge University Press, UK.
9. Riordan, Tim O' and Stoll-Kleemann, Susanne.2002. Biodiversity, Sustainability and Human Communities: Protecting Beyond the Protected. Cambridge University Press, UK.
10. Van Andel, J. and Aronson, J. 2005 Restoration Ecology: The New Frontier. Blackwell, UK.
11. Odum, E.P. 1991. Fundamentals of Ecology.W.B. Saunders, USA.
12. Primack, R.B.2010. Essentials of Conservation Biology. 5th ed. Sinaeur Associates, Inc., USA.
13. Singh, H.P., Batish, D.R. and Kohli, R.K. 2006. Handbook of Sustainable Weed Management. Haworth Press, Inc., USA.
14. Singh, J.S., Singh, S.P. and Gupta, S.R.2006. Ecology, Environment and Resource Conservation. Anamaya Publishers, New Delhi, India.
15. Townsend, Colin R. 2007.Ecological Applications: Toward a Sustainable World. Wiley-Blackwell

Name of Program	**M.Sc. Environmental Science**	**Program Code**	**ENV2**
Name of the Course	**Biostatistics and Environmental Modelling**	**Course Code**	**24EVS202DS03**
Hours per Week	**4**	**Credits**	**4**
Maximum Marks	**70**	**Time of Examination**	**3 hours**

Note: Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1: Familiarity with the basic knowledge of Biostatistics.
CLO 2: Selection of right choice of sampling method for research purpose.
CLO 3: Acquire skills for formulating research problems and hypotheses.
CLO 4: Identification of appropriate model for research conditions.
CLO 5: Applying right test to a problem to reach a conclusion.

Unit 1: Measurement of central tendency - mean (Geometric and Harmonic), median, mode, Measurement of dispersion moments, standard deviation, skewness and kurtosis, Correlation and linear regression of one independent variable, Basic laws and concepts of probability.

Unit 2: Definition of random variable, density function, Basic concepts of binomial and normal distributions. Sampling measurement and distribution of attributes, moments, matrices and simultaneous linear equations, tests of hypothesis and significance.

Unit 3: Role of modelling in environmental sciences, Model classification deterministic models, stochastic models, steady state models, dynamic models, different stages involved in model building. Simple microbial growth kinetics monod equation, methods for formulation of dynamic balance equations mass balance procedures.

Unit 4: Models of population growth and interactions Lotka-Volterra model, Leslies matrix model, Point source stream pollution, Box model, Gaussian plume model, Linear, simple and multiple regression models, validation and forecasting.

Suggested readings:

1. Kothari C.R. (2004). Research Methodology: Methods and Techniques (2nd ed). New Age International Publishers
2. Rastogi V. B. (2015). Biostatistics (3rd ed). MEDTECH
3. S.P. Gupta (1978) Elementary Statistical Methods, S. Chand Publications, New Delhi.
4. Spiegel, M.R., Stephens L.J. (2014). Statistics, (5th ed) Schaum's outlines, McGraw-Hill Education.
5. Masters, G. M & Ela, W. P (2015). Introduction to Environmental Engineering and Science (3rd ed). Pearson

Name of Program	M.Sc. Environmental Science	Program Code	ENV2
Name of the Course	Resource Management	Course Code	24EVS202DS04
Hours per Week	4	Credits	4
Maximum Marks	70	Time of Examination	3 hours

Note: Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1: Student will be able to get knowledge about resource management, management rangelands, watersheds, agricultural system.

CLO 2: Student will be able to learn about management of waste resources, forests, fresh water ecosystem effects of deforestation and conservation strategies for non- renewable energy resources.

CLO 3: Student will be able to understand how to prevent soil erosion, manage wasteland and soil conservation.

CLO 4: Students will be understood urban planning for India, Sustainable development, Land use policy for India.

CLO 5: Student will be understood the Ganga Action Plan and Yamuna Action Plan.

Unit 1: Resource management meaning & concept, management of rangelands & watersheds, management of Agricultural system

Unit 2: Management of waste resources, Management of forests, effects of deforestation. Management of fresh water ecosystem conservation strategies for non-renewable energy resources

Unit 3: Wildlife Management & conservation efforts for threatened species, Water Management Ganga Action Plan, Yamuna Action Plan, Environmental priorities in India

Unit 4: Reclamation & Management of waste lands, soil erosion, soil conservation, rural planning & land use pattern. Sustainable development, urban planning for India, Land use policy for India.

Suggested readings:

1. Owen, O.S. and Chiras, D.D. (1995) Natural resources conservation. Prentice Hall
2. Miller, G.T. and Spoolman S.E (2014) Living in Environment. Brooks/Cole Pub Co
3. Ramade, F. (1984) Ecology of natural resource. Wiley–Blackwell
4. Cunningham, W.P. and Saigo, B.W. (1994) Environmental Science. McGraw-Hill Inc.,US
5. Singh, J.S. (1993) Restoration of degraded lands: Concept and strategies. Rastogi Publications.

Name of Program	**M.Sc. Environmental Science**	**Program Code**	**ENV2**
Name of the Course	**Waste water treatment Technology**	**Course Code**	**24EVS202DS05**
Hours per Week	**4**	**Credits**	**4**
Maximum Marks	**70**	**Time of Examination**	**3 hours**

Note: Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1: Students would understand the water quality in relation to public health, principal forms of water pollution.

CLO2 Students gain knowledge about Pollution of stream, lakes, Ocean and Ground water pollution and how prevention will be attained.

CLO3 Students get exposure to various techniques used for monitoring pollution along with strategies for controlling pathogen transfer

CLO4 Students gain insight knowledge about primary, secondary and tertiary methods used for treatment of sewage and waste water along with biological methods concerning pollution control. Students would be able to assess the waste water.

Unit-1: Overview of standards of water quality in relation to public health - Potable and nonpotable Water; Methods of water sampling for pollution analysis. Principal forms of Water Pollutants and their sources; Pollution of stream, lakes and phenomenon of eutrophication; Ocean pollution – oil pollution; Ground water pollution and its control; Water pollution prevention.

Unit 2: Methods of monitoring Pollution; Biological methods; Detection methods for DO, BOD, Pathogen monitoring by heterotrophic plate count; Multiple tube method; Membrane filtration methods; Other emerging techniques such as enzyme detection, hybridization, PCR, Gene probe technology etc.; Strategies for controlling pathogen transfer; Chemical methods- Detection methods for COD, pH, alkalinity, TSS, TDS, Total organic carbon, oil, grease etc.; Biosensors for pollution.

Unit 3: Sewage and waste water treatments systems, Primary, secondary and tertiary treatments, Biological treatments - aerobic versus anaerobic treatments; Environmental pollution control- Bioremediation, Bioaugmentation and Biostimulation; Biofilms in treatment of waste water; Bioreactors for waste water treatments.

Unit 4: Physicochemical characteristics and treatment strategies for effluent generated by Distillery and fermentation industry; Fertilizers and pesticide manufacturing industries; Dyes and textile industries; Paper and pulp industries; Tanneries; Pharmaceuticals; Thermal power plants; Food and dairy industries; Iron and steel industries; Organic solvents; Chlorinated minerals and inorganic chemical industries and petrochemicals.

Suggested Readings:

1. Handbook of water and wastewater analysis (2007), Kanwaljit Kaur, Atlantic publishers and distributors (P) Ltd.
2. APHA(2023) Standard Methods For the Examination of Water and Wastewater, 24thEdition
3. Nicolas P Cherewsinott, Handbook of water and waste water Treatment Technology, Boston Oxford Auckland Johannesburg Melbourne, New Delhi
4. Frederick W Pontinus, Water Quality and Treatment. American water works Association, MC Graw Hill Inc

Name of Program	M.Sc. Environmental Science	Program Code	ENV2
Name of the Course	Techniques in Environmental Monitoring –II	Course Code	24EVS202SE01
Hours per Week	8	Credits	4
Maximum Marks	100		

Note: The practical exam of Techniques in Environmental Monitoring –II will be conducted at the end of semester. The question paper of practical will be prepared by external examiner, total marks of exam will be100.

Course Learning Outcomes (CLO):

CLO 1: Students would able to monitor the air pollution.
CLO 2: Students would able to measure the organic water pollution. They will learn about how to analyze the water quality.
CLO 3: Students would able to estimate soil pollution.
CLO 4: Students would get the sufficient knowledge to measure nutrients in water samples.

Experiments

1. To locate major renewable energy resources in the map of India.
2. To locate major non- renewable energy resources in the map of India.
3. To identify and locate major renewable and non- renewable resources in the world map.
4. To identify igneous, sedimentary and metamorphic rocks and their features.
5. To compare the biomass of the terrestrial and aquatic plant communities.
6. To study sampling methods used in biodiversity studies.
7. To determine the size of quadrate.
8. To determine the minimum number of quadrate
9. To determine the species frequency, species density and species cover by quadrate method.
10. To determine the Relative species frequency, relative species density and relative species cover by quadrate method and calculate the Importance Value.
11. Monitoring of Nitrogen Dioxide (NO_x) in the ambient air using modified Jacobs and Hochheiser method.
12. Monitoring of Sulphur Dioxide (SO_x) in the ambient air using Modified West and Gaeke method.
13. Monitoring of Suspended Particulate Matter (SPM) by filtration method using high volume sampler.
14. Monitoring of Carbon Monoxide (CO) using non-dispersive infrared spectrophotometer.
15. Measurement of heavy metals using Atomic Adsorption Spectrophotometer.
16. Measurement of Total Kjeldahl Nitrogen in a given water/soil sample.
17. Determination of amount of bleaching powder required to disinfect a water sample by Horrock's test.
18. To determine pH, Electrical Conductivity, turbidity, total solids, total suspended solids (TSS) and total dissolved solids (TDS) in given sample of water.
19. Measurement of sodium and potassium using flame photometer in a given water sample.
20. To determine the amount of oil and grease content present in the given water sample.
21. To determine phosphate content in a given sample of water.
22. To determine sulphate content in a given sample of water.
23. Measurement of Nitrate in given water sample using phenol disuphonic method.
24. Measurement of Ammonia in given water sample using nessler's reagent.
25. Measurement of fluoride in the given water sample using ion-selective fluoride meter.
26. To determine the total chlorine (residual) by Iodometric method.
27. To determine the minimum dose of a coagulant required to coagulate a given sample.
28. To study heavy metals present in given waste water sample by Atomic absorption spectrophotometer.
29. To determine Biochemical Oxygen Demand (BOD) of given industrial waste water sample.
30. To determine Chemical Oxygen Demand (COD) of given waste water sample

Semester –III

Name of Program	**M.Sc. Environmental Science**	**Program Code**	**ENV2**
Name of the Course	**Environmental Chemistry**	**Course Code**	**25EVS203DS01**
Hours per Week	**4**	**Credits**	**4**
Maximum Marks	**70**	**Time of Examination**	**3 hours**

Note: Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1 Students would understand the basic concept of stoichiometry with reference to chemical equillibria in carbonate system, hydrocarbons and radionuclides.

CLO2 Students would study about chemical processes occurring in atmosphere concerning with the formation of particles.

CLO3 Students would be able to develop experimental aptitude to analyse water quality parameters and treatment methods.

CLO4 Students would learn the chemistry of ozone, air, water quality treatment techniques and sewage and waste water treatment systems.

Unit 1: Stochiometry, Chemical potential, Chemical equilibria, acid-base.reactions. Solubility product, solubility of gases in water, the carbonate system, unsaturated and saturated hydrocarbons, Radio nuclides.

Unit 2: Classification of elements, chemical speciation, Particles, ions and radicals in the atmosphere. Chemical processes for formation of inorganic and organic particulate matter. Thermochemical and photochemical reactions in the atmosphere.

Unit 3: First law of thermodynamics, enthalphy, adiabatic transformations, second law of thermodynamics, Carnot's cycle, entropy, Gibb's free energy, phase equilibria, Gibb's Donnan equilibrium, third law of thermodynamics, enzymes catalysis, Michaelis/ Menten equation.

Unit 4: Oxygen and ozone chemistry, Chemistry of air pollutants, Photochemical Smog, Chemistry of water, concept of D.O., B.O.D., and C.O.D, water treatment : Sedimentation, Coagulation, Filtration, tertiary and advanced treatment, redox potential. Inorganic and organic components of soil, nitrogen pathways and NPK in soils.

Suggested readings:

1. Fundamental Concepts of Environmental Chemistry - G.S. Sodhi
2. Environmental Chemistry, Ninth Edition- Manahan, Stanley
3. Fundamentals of soil science - Henry D. Futh
4. Textbook of limnology - G.A. Cole
5. Environmental Chemistry - Sharma and Kaur

Name of Program	M.Sc. Environmental Science	Program Code	ENV2
Name of the Course	Elementary Concept of Physical Environment	Course Code	25EVS203DS02
Hours per Week	4	Credits	4
Maximum Marks	70	Time of Examination	3 hours

Note: Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1 Students will be able to Study of ecosystems and their components will lead towards the interaction between Man and Earth.

CLO2 Students will be able to understand the structure and composition of Earth and its biomes.

CLO3 Students gain knowledge about the atmospheric changes and climate of different regions.

CLO4 Students gain sufficient knowledge about meteorology and clouds.

UNIT – I

Definition, Principles and scope of Environmental Science. Earth, Man and Environment, Ecosystem, Pathways in Ecosystems, Physico- chemical and biological factors in the Environment.

UNIT - II

Geographical classification and zones. Structure and composition of Biosphere. General relationship betwee landscapes, biomes and climates. Atmospheric instability, inversions and mixing heights, wind roses.

UNIT - III

Primary differentiation and formation of core, mantle and crust. Igneous, sedimentary and metamorphic roc weathering, erosion, transportation and deposition of earth's material by running water, wind and glaciers.

UNIT - IV

Mass and energy transfer across the various interphases, Material Balance, Heat Transfer processes, scales of Meteorology, various kinds of lapse rates, vertical stability of atmosphere, cloud classification & formation.

Suggested readings:

1. Ecology and Environemnt - P.D. Sharma
2. Concepts of physical environment- Savinder Singh
3. Atmosphere, The: An Introduction to Meteorology- Frederick Lutgens, Edward Tarbuck and Redina Herman
4. Atmosphere, Weather, and Climate: An Introduction to Meteorology- John Gabriel Navarra

Name of Program	**M.Sc. Environmental Science**	**Program Code**	**ENV2**
Name of the Course	**Environmental Impact Assessment**	**Course Code**	**25EVS203DS03**
Hours per Week	**4**	**Credits**	**4**
Maximum Marks	**70**	**Time of Examination**	**3 hours**

Note: Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1 Students will able to analyse and document the Environmental impact by understanding the Environmental guidelines in India.

CLO2 Students will able to describe the generalised approach to impact assessment and monitor environmental impact assessment methodologies with reference to case studies.

CLO3 Students will able to learn the baseline information, environmental auditing and land use policy in India.

CLO4 Students will able to examine environmental risk by its assessment and management by understanding the steps involved.

UNIT – I

Introduction to environment impact analysis, Environmental impact statement and Environmental management plan, ISO14000, EIA guidelines 1994, Notification of Govt. of India.

UNIT – II

Impact assessment methodologies, Generalized approach to impact analysis. Case study: EIA of some dam, procedure for reviewing Environmental impact analysis and statement.

UNIT - III

Guidelines for Environmental Audit, Baseline information and prediction (land, water, atmosphere, energy), Restoration and rehabilitation technologies, Land use policy for India.

UNIT - IV

Risk analysis - definition of risk, Environmental risk analysis, risk assessment and risk management, Basic steps in risk assessment - hazard identification, dose- response assessment, exposure assessment, Risk characterization.

Suggested readings:

1. Introduction To Environmental Impact Assessment, 5th edition - John Glasson and Riki Therivel
2. Methods of Environmental Impact Assessment - Morris and the rivel- Peter Morris and Riki Therivel
3. Environmental Imapct Assessment - L. W. Canter.
4. Chemical principles of Environmental pollution - Lalloway and Ayers.
5. Industrial Environment Assessment and Strategy- Shyam Kishor Agarwal.

Name of Program	M.Sc. Environmental Science	Program Code	ENV2
Name of the Course	Remote Sensing and Geological Information Technology	Course Code	25EVS203DS04
Hours per Week	4	Credits	4
Maximum Marks	70	Time of Examination	3 hours

Note: Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1 Student gets an understanding of the main concepts that define Geographic Information systems and their application in the environmental and life sciences.

CLO2 Students would learn how pictures of the earth's surface are recorded from aircraft and satellites and interpret properly Remote Sensing Images.

CLO3 Students gain an understanding of Remote Sensing products such as earth resources, satellite images, aerial photographs as well as more sophisticated research tools such as RADAR and multispectral scanner systems.

CLO4 Students would learn to assess the usefulness of different types and scales of remotely sensed data via on the ground comparisons.

CLO5 Students would learn environmental remote sensing and GIS which can directly enhance service delivery on land use management, ground water management/prospects, agriculture, forestry, food and water security, disaster management, etc.

Unit 1: Definition, Introduction and scope of remote sensing. Electromagnetic radiation, atmosphere window, Platforms, Sensors and type of scaning systems. Basic characteristics of sensors; salient features of sensors used in LANDSAT, SPOT and Indian remote sensing satellites.

Unit 2: Aerial photography- vantage point, cameras, Filters and types of films. Elements of visual image interpretation. Multispectral Remote sensing, Microwave Remote sensing, Photogrammetry - Introduction, Stereo- scopic vision, Projection types.

Unit 3: Digital image and image structure, Image restroration and image and image enhancement. Image classification. Remote sensing application in Forestry, Ecology and environment, Landuse, Agriculture, soils and geology, Disaster management.

Unit 4: GIS technology and its uses in environmental science, Hardware and software requirement for GIS. Conceptual model of spatial information, Conceptual model of non spatial information. GPS.

Suggested readings:

1. Introduction to Environmental Remote Sensing- Eric C. Barrett and Leonard F. Curtis
2. Principles of Remote sensing - Lily and kliffer.
3. Remote sensing of the Environment –: an earth resource perspective, 2nd edition- Jensen

Name of Program	**M.Sc. Environmental Science**	**Program Code**	**ENV2**
Name of the Course	**Environmental Microbiology**	**Course Code**	**25EVS203DS05**
Hours per Week	**4**	**Credits**	**4**
Maximum Marks	**70**	**Time of Examination**	**3 hours**

Note: Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1 Students would understand microbiology, microbial reactors, and biogas technology.

CLO2 Students would learn about basic concepts of environmental planning and about land use planning and its methods

CLO3 Students would be able to understand the principle and working of Batch culture, continuous culture, and various technologies of biogas production.

CL4 Students would know about the biotransformation, bioconversion, bioremediation and various environmental monitoring techniques through microorganisms.

Unit 1: Microbiology- organisms in nature & their importance, sampling, culture & cultivation of microorganisms, microbes in service of nature & mankind, Batch culture & continuous culture of microbes for commercial use.

Unit 2: Microbial Reactors, genetically modified microbes & their uses in Environmental management recycling & up gradation technologies, Production of products, energy form waste.

Unit 3: Biogas technology, plant design, construction, operation, biogas form organic wastes, water weeds, landfills, microbiology of anaerobic fermentation.

Unit 4: Biotransformation, bioconversion, bioremediation, phytoremediation technology, fermentation technology, development of stress tolerant plants, Environmental problems & Environmental monitoring through microorganism, microbiology of water, air and soil, microbes as pathological agent in plant, animal and man.

Suggested readings:

1. Principles of microbiology - Pelzar
2. Microbial Biotechnology: Fundamentals of Applied Microbiology 2nd Edition- by Alexander N. Glazer and Hiroshi Nikaido
4. Microbial Ecology: Fundamentals and Applications- Ronald M. Atlas and Richard Bartha
5. Molecular biology second edition - H.D. Kumar
6. Environmental Biotechnology for Waste Treatment: Gary S. Sayler, Robert Fox and James Blackburn

Name of Program	**M.Sc. Environmental Science**	**Program Code**	**ENV2**
Name of the Course	**Techniques in Environmental Monitoring –III**	**Course Code**	**25EVS203SE01**
Hours per Week	**8**	**Credits**	**4**
Maximum Marks	**100**		

Note: The practical exam of Techniques in Environmental Monitoring –III will be conducted at the end of semester. The question paper of practical will be prepared by external examiner, total marks of exam will be100.

Course Learning Outcomes (CLO):

CLO1 Students will understand the applicability of stoichiometry in real world.
CLO2 Students will able to develop experimental aptitude to analyse water quality parameters.
CLO3 Students would be able to visually interpret landset imagery of various geographic regions.
CLO4 Students would learn geo-referencing from toposheet in ERDAS domain.

Experiments

To study the annotation on given image or imagery and write discussion.
2. To study the imagery of different sensors and discuss the comparison.
3. To study out the construction and operation of multiband ground truth radiometer.
4. To determine percentage of reflection of different object using radiometer.
5. To differentiate different object by using multispectral remote sensing.
6. To calculate the vegetative index of vegetation by radiometer.
7. To study the visual interpretation of imagery.
8. Georeference the imagery with toposheet by image to image method
9. Georeference the imagery through keyboard method.
10. To find λmax value of $K_2Cr_2O_7$ and $KMnO_4$ solution using spectrophotometer.
11. To plot standard curve for Cr(VI) using $K_2Cr_2O_7$ and to find concentration of Cr(VI) in unknown sample.
12. To determine the concentrations of heavy metals present in the water/soil samples.
13. Environment impact assessment case studies of
    a) Hyrdoelectric Power Project.
    b) Thermal Power Project.
    c) Coal Mining Project.
    d) Oil Refinery.
    e) Ports and Harbours.
    f) Natural Gas Power Plant.
    g) Fertilizer Plant
    h) Nuclear Power Project
    i) Roads and Highways
    j) Railway Project.
14. Isolation and enumeration of microbes from soil sample by serial dilution agar plating method or by viable plate count method.
15. Bacteriological tests for potability of water
    a. MPN, Confirmed and Completed test.
    b. Membrane filter technique

Semester- IV

Name of Program	**M.Sc. Environmental Science**	**Program Code**	**ENV2**
Name of the Course	**Environmental Laws**	**Course Code**	**25EVS204DS01**
Hours per Week	**4**	**Credits**	**4**
Maximum Marks	**70**	**Time of Examination**	**3 hours**

Note: Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes:

CLO1 Students would learn eco-friendly techniques i.e. eco-marks and provisions given in the constitution of India regarding environment.

CLO2 Students would be able to describe of environmental policy resolution, legislation and public policy strategies in pollution control with reference to wildlife protection act 1972 and its amendment in 2002, forest conservation act 1980 and India forest act 1927.

CLO3 Students would learn to analyse the environmental issues and problems with national and international efforts for environment protection with special reference to the water (prevention and control of pollution) Act 1974, its amendment 1978 and rules 1975.

CLO4 Students would understand the efforts done at national and international level for environmental protection issues and problems.

UNIT - I

Scheme of lebelling of environmentally friendly products (ecomark). Public liability Insurance Act. 1991. Provision of constitution of India regarding environment [article 48 A & 51A(g)].

UNIT – II

Environmental policy resolution, legislation, public policy strategies in pollution control. Wild life protection act, 1972 amended 2002. Forest conservation act, 1980. Indian forest act 1927.

UNIT - III

Air (prevention & control of pollution) Act 1981 as amended by amendment 1987 & rule 1982. Motor vehicle act, 1988, The environment (protection) Act, 1986, rules 1986.

UNIT – IV

The water (prevention & control of pollution) Act, 1974 as amended by amendment 1978 & rules 1975. Environment protection issues & problems, international & national efforts for environment protection.

Suggested readings:

1. Environmental administration & law - Paras Diwaa.
2. Environmental planning, policies & programs in India - K.D. Saxena.

Name of Program	M.Sc. Environmental Science	Program Code	ENV2
Name of the Course	Environmental Management and Planning	Course Code	25EVS204DS02
Hours per Week	4	Credits	4
Maximum Marks	70	Time of Examination	3 hours

Note: Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes:

CLO1 Students will get aware about role of NGO's in environmental movements and know about various international initiatives in environment.

CLO2 Students will be learn the effects of air pollution, fly ash utilization and eutrophication process.

CLO3 Students will come to know about basic concepts of environmental planning and about land use planning and its methods

CLO4 Students will come to know about Environmental Sustainability and Cost-benefit analysis and will get aware about various International convention and treaties for Sustainable development.

UNIT - I

Role of NGO's public participation in environmental movements, Concepts of Environmental education and awareness Internationals environmental initiatives – the club of Rome report, Stockholm Declaration, environmental ethics.

UNIT - II

Vehicular pollution and urban air quality, Fly ash utilization, Eutrophication and restoration of Indian lakes, Wet land conservation, Water crisis-conservation of water. Narmada dam, Tehri dam, Almetti dam.

UNIT - III

Basic concepts of environmental planning, Environmental priorities in India, Land use planning : The land use plan (India). Soil surveys in relation to land use planning. Methods of site selection and evaluation, global imperatives, soil erosion, Formation and reclamation of Usar, alkaline and saline soil, waste lands and their reclamation, Desertification and its control.

UNIT - IV

Urban planning and rural planning for India. Sustainable development- principles and practices in relation to economics and ecology. Cost-benefit analysis- its relevance. Ramsar convention on wetlands, Vienna convention and Montreal Protocol, Kyoto protocol, Earth Summit, Agenda-21.

Suggested readings:

1. Natural Resource Conservation: Management for a Sustainable Future Hardcover- Oliver S. Owen, Daniel D. Chiras and John P. Reganold
2. Environmental planning, policies and programs in India- K.D. Saxena.
3. Conservation Ecology- G.W.Cox.
4. Global Biodiversity - W.R. L. IUCN

Name of Program	M.Sc. Environmental Science	Program Code	ENV2
Name of the Course	Environmental Geology	Course Code	25EVS204DS03
Hours per Week	4	Credits	4
Maximum Marks	70	Time of Examination	3 hours

Note: Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes:

CLO1 Students would gain knowledge about various earth processes, hydrological cycles and Biogeochemical cycles, Tectonic cycle, Rock cycle.

CLO2 Students would gain knowledge about catastrophic geological hazards and their causes and effects.

CLO3 Students would learn the geology of mineral resources, EIA of mineral development, Methods of extraction of mineral resources and recycling of mineral resources.

UNIT-I

Earth processes, Geological cycle, Tectonic cycle, Rock cycle, Hydrological cycle, Biogeochemical cycles, Special problems of time and scale in geology, concept of residence time and rates of natural cycles.

UNIT-II

Catastrophic geological hazards, Prediction and perception of the hazards and adjustment to hazardous activities. Predictions and perception of hazard and adjustment to hazardous activities.

UNIT-III

River flooding- causes, nature and frequency of floods. Landslides- causes, intensity and magnitude. Volcanism nature extent and causes, Volcanism and climate. Avalanches causes and effects.

UNIT-IV

Mineral and human use, geology of mineral resources, EIA of mineral development, Methods of extraction of mineral resources, recycling of mineral resources.

Suggested readings:

1. Introduction to Environmental geology-Edward A. Keller
2. Environmental geology-Carla W. Montgomery
3. Physical Geology of India-National book trust series- S M Mathur

Name of Program	M.Sc. Environmental Science	Program Code	ENV2
Name of the Course	Academic Writing	Course Code	25EVS204DS04
Hours per Week	4	Credits	4
Maximum Marks	70	Time of Examination	3 hours

Note: Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes:

CLO 1: Students will learn about academic writing.
CLO 2: Students will have ideas to identify and avoid plagiarism.
CLO 3: Students will learn writing skills for research papers, reviews, and thesis writing.
CLO4: Scientifically acknowledge different sources of information in their writings

Unit 1: Introduction to Academic writing: Basic rules of academic writing; Importance of report writing in academics and research; Characteristics of educational and research reports/presentations.
Forms of Academic Writing: Abstract writing; summarization; review of literature; scientific poster presentations; reflective, analytic and descriptive reports; book review; film review; tables and graphs in academic papers.

Unit 2: Research paper writing: Types of research papers, Structure of research papers, Research paper formats (Abstract writing, Methodology, Results and discussions), Ways of communicating a research paper.
Writing research proposals: Writing project proposals, Progress/utilization reports, Scientific reports, etc.
Thesis writing: Structure of a thesis, introduction, Literature review, Experimental/computational details, Results and Discussions, Figures and Tables preparation, Conclusions, and future works, Bibliography, Appendices; Usage of line, bar-graphs, charts to describe the results.

Unit 3: Presentation of research: title of the study, aims and objectives; format of research; pagination; grammar, punctuation and the conventions of academic writing: organization of materials; in-text citations; list of works cited; footnotes and endnotes; research findings; Different formats for referencing, bibliography; using standard style.

Unit 4: Plagiarism: Introduction; Tools for the detection of plagiarism; Avoiding plagiarism;
Ethics in Research (Research fraud, competing interest, authorship); Publication ethics: definition, introduction, and importance; Conflicts of interest; Copyright and Ethical issues in paper writing
Databases and research metrics: Databases: Indexing databases, Citation databases (Web of Science, Scopus, etc); Research Metrics (Impact Factor of the journal as per Journal Citation Report, SNIP, SIR, Cite Score & Metrics (h-index, g index, i10 index)

Suggested readings:

1. Chindhade, S. and A. Thorat (2009), An Introduction to Research, Mumbai: Cambridge University Press.
2. Abdul Rahim, F. (2005), Thesis Writing: A Manual for Researchers, New Delhi: New Age International.
3. MLA Handbook for Writers of Research Papers (7th edn. 2009), New York: MLA Association.

Name of Program	**M.Sc. Environmental Science**	**Program Code**	**ENV2**
Name of the Course	**Climate Change and Sustainability**	**Course Code**	**25EVS204DS05**
Hours per Week	**4**	**Credits**	**4**
Maximum Marks	**70**	**Time of Examination**	**3 hours**

Note: Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing short answer type questions from all units. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each Unit. All questions will carry equal marks.

Course Learning Outcomes:

CLO 1: Identify, list environmental, social, and economic impacts of anthropogenic activities and required sustainability framework for mitigation.

CLO 2: Discuss the anthropogenic and natural drivers of climate change and future development aspects for sustainability.

CLO 3: Analyze the impacts of climate change and compare with the future goals of sustainability.

CLO 4: Compare different policies and agreements regarding climate change and developmental goals.

Unit 1: Climatic Systems and Variations: Global Climate System, Causes for Modern Climate & Climate Change Consequences and Challenges: Impacts on Life, Vegetation, Fauna, Glaciers and Ice Sheets Melting, Sea Level Changes, Economics of Climate Change, Climate Change adaptation and Mitigation measures.

Unit 2: Confronting Climate Change: Policies and Efforts
International Response: UNFCCC and Conference of the Parties, Special Reports by IPCC, Kyoto Protocol, Bali Road Map and Agreements, Copenhagen Conference.
National Response: National Action Plan on Climate Change (NAPCC) and 8 National Missions on Climate Change, State Action Plan on Climate Change (SAPCC), National Adaptation Fund on Climate Change (NAFCC), India's Post-2020 Climate Goals, Climate Change Action Programme (CCAP), National Carbonaceous Aerosols Programme (NCAP), LiFE Mission, Global Alliances.

Unit 3: Origins of Sustainable Development: Definition, Evolution and Principles, Brundtland Report, Strategies for Sustainable Development, Sustainability and Human Development, Cultural Elements in Sustainable Development Frameworks, Sustainable Development Goals (SDGs) and Issues, Public Engagement in Sustainable Development.

Unit 4: Environmental Society Governance (ESG) and Sustainability, Corporate Social Responsibility (CSR), Urbanization and Sustainable Cities.
Appropriate Technology and Sustainability Science, Corporate Sustainability, Sustainability Metrics and Indices, Ecological and Carbon Footprint for Sustainability Measurement, Sustainability Measurement and Reporting Tools.

Suggested readings:

1. D. T. Allen and D. R. Shonnard, Sustainability Engineering: Concepts, Design and Case Studies, 1st Edition, Prentice Hall, 2001.
2. H.S. Sharma S. Padmaja and Ganesh Sharma, Climate Change Biodiversity and Green Economy, Concept Publishing Company Pvt. Ltd. (2013).
3. A. S. Bradley, A. O. Adebayo, and P. Maria, Engineering Applications in Sustainable Design and Development, 1st Edition, Cengage Learning, 2015.
4. K. M. Mackenthun, Basic Concepts in Environmental Management, 1st Edition, Lewis Publishers, 1998.
5. Bureau of Energy Efficiency, Energy Conservation Building Code (ECBC), 1st Edition, Bureau of Energy Efficiency, New Delhi, 2007.
6. N. B. Chang, Systems Analysis for Sustainable Engineering: Theory and Applications, 1st Edition, McGraw-Hill Professional, 2011.
7. J. W. Twidell and A. D. Weir, Renewable Energy Resources, 2nd Edition, Taylor & Francis, 2006.

Name of Program	M.Sc. Environmental Science	Program Code	ENV2
Name of the Course	Environmental Data Handling and Statistics	Course Code	25EVS204SE01
Hours per Week	8	Credits	4
Maximum Marks	100		

Note: The practical exam of Environmental Data Handling and Statistics will be conducted at the end of semester. The question paper of practical will be prepared by external examiner, total marks of exam will be100.

Course Learning Outcomes (CLO):

CLO1 Students will learn to handle the data generated in real world.
CLO2 Students will able to apply statistical tools to analyse the experimental data.
CLO3 Students would be able to interpret the results and generate valid conclusions .
CLO4 Students would learn the calculation of various environmental indices used for data reporting

Experiments

1. To measure and analyze noise levels in different environments using sound meter.
2. To measure the concentration of particulate matter (PM10 and PM2.5) in ambient air using air sampler.
3. To analyze and classify solid waste into different categories based on its physical, chemical, and biological characteristics for effective management and disposal.
4. To measure the concentration of sulphur dioxide (SO_2) in ambient air using standard sampling and analysis methods.
5. To measure the concentration of nitrogen oxides (NOx) in ambient air using standard sampling and analysis methods.
6. To perform one-way ANOVA to compare the water quality parameters of different locations.
7. To perform a chi-square test for analyzing the relationship between waste segregation practices.
8. To apply Pearson's correlation on water quality paramters.
9. To assess difference in noise level across various location or time using ANOVA.
10. To measure the concentration of Total Suspended Particles (TSP) in ambient air using standard sampling and analysis method.
11. To measure the concentration of inorganic ions such as sulfates (SO_4^{2-}), nitrates (NO_3^-), and ammonium (NH_4^+) using High Volume Air Sampler.
12. Analyzing biodiversity in a specific area by conducting a field survey to map species distribution with the help of GIS.
13. To analyze how changes in land use (e.g., urbanization, deforestation) affect environmental quality indicators such as air quality, water quality, or biodiversity.
14. To assess how soil quality parameters (e.g., pH, organic matter content, nutrient levels) affect crop yield.
15. To determine the sensitivity of certain environmental parameters (e.g., vegetation growth, water availability) to changes in climate conditions.
16. To apply statistical quality control techniques (e.g., control charts, process capability analysis) to environmental data to monitor consistency and identify outliers.
17. To evaluate vegetation diversity in a given area using the quadrat sampling method and calculate the species richness index.
18. To monitor the heat island effect by recording temperature variations in urban and rural areas using a portable temperature logger.
19. To assess water quality using the Water Quality Index (WQI) by analyzing parameters such as pH, dissolved oxygen, turbidity, and nitrate levels.
20. To perform soil texture analysis using the hydrometer method and classify soils based on the USDA soil texture triangle.