The Poona Gujarati Kelavani Mandal's

Haribhai V. Desai College of Arts, Science and Commerce, Pune
(Autonomous)

Faculty of Science and Technology

STRUCTURE AND SYLLABUS

TWO YEAR MASTERS PROGRAMME IN

ENVIRONMENTAL SCIENCE

Title of the Program

M. Sc. Environmental Science

Based on NEP 2020

Effective from Academic year 2024 – 2025

To be implemented from Academic Year: 2024-25

Faculty	**Science**
Program	**Environmental Science**
Class	**M. Sc. I**

Preamble

The syllabus of Two-year Masters Programme in Environmental Science is presented here as an outcome of deliberations amongst distinguished academia and on the skill and demands of the industry. It aims at catering to impart skills and knowledge to budding Environmentalist so that they may provide an informed choices and solutions to a plethora of national and international environment-based industries. It also aims at equipping students at developing cutting-edge solutions and technologies that can prove fruitful in monitoring, nurturing, preserving and predicting environmental issues in the new paradigm of global warming and climate change. It is thus designed for students interested in studying environmental problems from a scientific perspective.

The syllabus for the two years Masters Programme (M.Sc.) in Environmental Sciences under the Faculty of Science and Technology offered by the Haribhai V. Desai College is interdisciplinary in nature and has been prepared under the Credit Framework guidelines of National Education Policy (NEP) 2020. The Master's programme is divided into two distinct Academic years consisting of two semesters for First year and two semesters for the second year. The two-year programme i.e. Masters in Environmental Sciences amounts to a sum of minimum 88 credits, with minimum of 22 credits for each semester. If a student chooses to exit at the end of first year as per the NEP 2020, he/she will be awarded a Post Graduate Diploma in Environmental Sciences, provided he completes all necessary credits as per guidelines. The Masters and Diploma programme are comprehensive and contain multidisciplinary courses that can be broadly classified into Major Core, Major Electives, and Research Methodology courses, each semester, the student can choose subjects from a 'basket of Elective Courses' on offer. Students are encouraged to select interdisciplinary science subjects on offer across the School or University campus. Besides, Research Projects (Masters Dissertations) and On Job Training (Internship) are also designed and included in this syllabus to offer a plethora of research based and skilled based learning experiences.

This programme will involve teaching-learning activities by class-room teaching and conducting practicals in laboratories. It will involve learning concepts through presentations, black board teaching, group discussions and student assignments. In addition, fieldworks related to Forest and wildlife, and visits to field based best practices, environment-based industries, laboratories of national/international repute, botanical and zoological gardens, etc. will also be included and encouraged during the semester breaks. Students will submit field

reports for evaluation after such activities.

The PG Diploma and Masters students will be assessed through a Continuous Assessment (CA) and End Semester Assessment (ESA). Candidates will be examined and evaluated under grade system at the end of each semester separately for theory and practical papers as per the credits offered by each course.

The overall aim of this new syllabus is to empower our students to acquire skills and competence so as to adopt careers in environmental science sector and to serve the Nation and global industries in the solving the problems and perils faced by Mother Earth.

1. Objectives

i. To develop scientific understanding and analytical approach for mitigating Environmental problems with remediation and restoration techniques

ii. To generate awareness about future and current Environmental Issues and fulfil our social obligation.

iii. To develop understanding of interdisciplinary nature of the subject, its applicability and significance

iv. To impart skills so that students can apply their understanding in planning and conservation efforts.

2. P. G. Structure of the Programme:

Each M.Sc. programme is of 2 years duration. The minimum total no. of credits requirement for each programme is 88. In the structure, the credits are distributed over 4 semesters

Level	Semester	Credits Related to Major		Research Methodology (RM)	Internship/ On Job Training (O/T)	Research Project (RP)	Total
		Major Core	Major Elective				
6.0	I	10 (T) + 4 (P)	2 (T) + 2 (T/P)	4	0	0	**22**
	II	10 (T) + 4 (P)	2 (T) + 2 (T/P)	0	4 (O/T)	0	**22**
Exit option: Award PG Diploma on completion of 44 credits after three years UG Degree **OR** continue with PG second year							
6.5	III	10 (T) + 4 (P)	2 (T) + 2 (T/P)	0	0	4	**22**
	IV	8 (T) + 4 (P)	2 (T) + 2 (T/P)	0	0	6	**22**
Total 2 Years		**54**	**16**	**4**	**4**	**10**	**88**
2 years-4 Sem. Award PG Degree on completion of 88 credits. After Three Years UG Degree or 1 Year- 2 Sem PG Diploma (44 credits) after Four Year UG degree							

3. Credits in hours

ii) Each credit will be equivalent to 15 clock hours of teaching

iii) Credit: A unit by which the course work is measured. It determines the number of hours of instructions required per week. One credit is equivalent to one hour of teaching (theory) or two hours of practical work/field work per week.

Course Structure and assessment of credits:

Each M.Sc. Programme is of 2 years duration. The minimum total no. of credits requirement for each programme is 88. In the structure, the credits are distributed over 4 semesters. The open elective included in each semester, gives the student a wide choice of subjects from other programmes.

Total credits:

A full masters' degree course in science would be of 88 credits. One credit course of theory will be of one clock hour per week, running for 15 weeks and one credit for practical course will consist of 30 clock hours of laboratory exercises. One credit is equivalent to one hour of teaching (theory) or two hours of practical work/field work per week. There shall be four semesters and credits are distributed over 4 semesters. There will be 2 core compulsory theory courses (4 credits each), one core compulsory theory course (2 credits) and one core compulsory Practical course (4 credits). In addition to this, choice based optional paper means elective courses are offered consisting of 2 theory credits courses and allied 2 practical credit courses. There are also Research Methodology (RM), Internship/ On the Job training (O/T) and Research Project credits assigned to a particular semester.

4. Evaluation Pattern:

Examination Rules

1. A student cannot appear for semester end examination unless he/she has maintained 75% attendance during the teaching period of that course. If a student fails to maintain attendance up to 75%, at the time of filling of examination forms, an undertaking the student should be taken stating that he/she will be allowed to appear for examination subject to fulfilment of required attendance criteria during the remaining period of teaching of the course.
2. Each course carrying 100 marks shall be evaluated with Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) mechanism.
3. Continuous Internal Evaluation shall be of 40 marks (.40%) while Semester End Examination shall be of 60 marks (60%). To pass in a course, a student has to secure minimum 40 marks (40%) provided that he should secure minimum 24 marks (40%) in Semester End Examination (SEE) and 16 marks (40%) in Continuous Internal Evaluation (CIE).
4. Each credit will have a Continuous Internal Evaluation (CIE) of 40% of marks and a teacher must select a variety of procedures for examination such as:

a. Written Test and/or Mid Term Test (not more than one each course)

b. Term Paper;

c. Viva-voce,

d. Projects / Surveys / Field visits,

e. Tutorials,

f. Group Discussion

g. Journal/Lecture/Library notes;

h. Seminar presentation;

i. Short Quizzes;

j. Assignments;

k. Extension Work;

l. Research Project by individual students or group of students; or

m. An Open Book Test (with the concerned teacher deciding what books are to be allowed for this purpose.) etc (on approval of the head of the centre)

n. Field Work: Fieldwork/visits is compulsory wherever applicable. Evaluation will be based on Performance of the student in the field, field diary and comprehensive field visit report

5. If a student misses a Continuous Internal Evaluation (CIE), he/she will have a second chance with the permission of the teacher concerned. Such a second chance shall not be the right of the student; it will be the discretion of the teacher concerned to give or not to give second chance to a student to appear for internal assessment.

6. The research project course will be evaluated on the basis of viva voce conducted at the end of semester. A separate mechanism will be declared to evaluate the research project which will include the weightage to publication in journal or presentation in conference.

7. Students who have failed semester-end exam may reappear for the semester-end exam in the subsequent period. The student will be finally declared as failed if he/she does not pass in all credits within a total period of four years in case of two-year courses and five years in case of three-year courses. After that, such students will have to seek fresh admission as per the admission rules prevailing at that time.

8. Internal marks will not change. A student cannot repeat internal assessment. In case he/she wants to reappear for the internal assessment he/she can do so only by registering for the said courses during the semesters in which the courses are being conducted.

9. There shall be revaluation of the answer scripts or semester-end examination papers only but not of internal assessment papers

10. While marks will be given for all examinations, they will be converted into grades. The semester end and final grade sheets and transcripts will have only grades and grade points average.

11. Except for the technology faculty, in subjects or departments where project work is pan

of the credits, the project will consist of not more than ten percent of the total credits for the degree course.

5. ATKT Rules:

A student cannot register for the third semester, if he/she fails to complete 50% credits of the total credits expected to be ordinarily completed within two semesters. In this case, a student can seek admission to first or second semester in order to complete the requisite number of credits and to be able to seek admission in the third semester.

6. Completion of Degree Course:

1. A student, who earns 88 credits, shall be considered to have completed the requirements of the M. Sc. degree program and CGPA will be calculated for such student.

2. The following percentage to grade and grade point is given in Table

Table: Percentage to Grades and Grade Points

Sr. No.	Grade Letter	Grade Point	Marks
1	O Outstanding	10	90 ≤ Marks ≤ 100
2	A+ Excellent	9	75 ≤ Marks ≤ 89
3	A Very Good	8	60 ≤ Marks ≤ 74
4	B+ Good	7	55 ≤ Marks ≤ 59
5	B (Above Average)	6	50 ≤ Marks ≤ 54
6	C (Average)	5	45 ≤ Marks ≤ 49
7	D (Pass)	4	40 ≤ Marks ≤ 44
8	F (Fail)	0	Marks < 40
9	Ab (Absent)	0	

7. Standard of Passing:

To pass in a course, a student has to secure minimum 40 marks (40%) provided that he should secure minimum 24 marks (40%) in End- Semester Assessment and 16 marks (40%) in In-Semester continuous assessment

8. Award of Class:

A student, who earns 88 credits, shall be considered to have completed the requirements of the M. Sc. degree programme and CGPA will be calculated for such student**.**

9. Verification/Revaluation:

There shall be revaluation of the answer scripts of semester-end examination of theory papers

only but not of internal assessment papers.

10. Eligibility for Admission

Eligibility to take admission for first year of M.Sc. programme in the environmental science subject is that the student has completed three-year bachelor degree in ANY SCIENCE major. Students with bachelor degree with 50% marks in the following are eligible;

a. Bachelor of any Science (Environmental Science, Botany, Zoology, Chemistry, Microbiology, Biotechnology, Physics, Mathematics, Statistics and all other Science graduates OR
b. Bachelor in Engineering any branch. OR
c. Bachelor of Science in Agriculture, Fisheries. OR
d. Bachelor of Pharmacy. OR
e. B. Sc. (Blended) Environmental Science OR
f. B.Sc. Nanoscience and Nanotechnology OR
g. B. Sc. Fire and Safety.

11. **Medium of Instruction**: English

12. **Award of Class**:

A student, who earns 88 credits, shall be considered to have completed the requirements of the M. Sc. degree programme and CGPA will be calculated for such student.

Question Paper Pattern

External Question Paper Pattern for 4 Credit Paper

Total No. of questions: **Total No. of pages:**

The Poona Gujarati Kelavani Mandal's
Haribhai V. Desai College of Arts, Science and Commerce, Pune – 02
(Autonomous)
_____ Year M. Sc. Environmental Science
Subject Code: Subject title
(NEP 2020 Pattern) (Semester)

Time: _____ **Max Marks: 60**

Instructions to the candidates:

1. ***All questions are compulsory.***
2. ***All questions carry equal marks.***

Q1		**Attempt any five of the following.**	**10**
	i.		
	ii.		
	iii.		
	iv.		
	v.		
	vi.		
Q2	**A]**	**Attempt any four of the following**	**12**
	i.		
	ii.		
	iii.		
	iv.		
	v.		
Q3	**A]**	**Attempt Any two of the following**	**08**
	i.		
	ii.		
	iii.		
	B]	**Attempt the following**	**04**
Q4	**A]**	**Attempt any two of the following**	**06**
	i.		
	ii.		
	iii.		

	B]	**Attempt the following**	**04**
Q5		**Attempt any two of the following**	**08**
	i.		
	ii.		
	iii.		
Q6		**Attempt any two of the following**	**08**
	i.		
	ii.		
	iii.		

Question Paper Pattern

External Question Paper Pattern for 2 Credit Paper

Total No. of questions: **Total No. of pages:**

The Poona Gujarati Kelavani Mandal's
Haribhai V. Desai College of Arts, Science and Commerce, Pune – 02
(Autonomous)
_____ Year M. Sc. Environmental Science
Subject Code: Subject title
(NEP 2020 Pattern) (Semester)

Time: _____ **Max Marks: 30**

Instructions to the candidates:

3. ***All questions are compulsory.***
4. ***All questions carry equal marks.***

Q1		**Attempt any three of the following.**	**06**
	i.		
	ii.		
	iii.		
	iv.		
Q2	**A]**	**Attempt any two of the following**	**06**
	i.		
	ii.		
	iii.		
	B]	**Attempt the following**	**02**
Q3	**A]**	**Attempt Any one of the following**	**03**
	i.		
	ii.		
	B]	**Attempt the following**	**05**
Q4	**A]**	**Attempt any one of the following**	**03**
	i.		
	ii.		
	B]	**Attempt the following**	**05**

Internal Question Paper Pattern for 4 Credit Paper

PGK Mandal's

Haribhai V. Desai College of Arts, Science and Commerce (Autonomous)
Internal Exam - Semester
Department of Environmental Science

Subject Code: Subject Name

Date: **Max marks: 40** **Time:**

1. Answer the following questions. **(5 x 2 =10 marks)**

a. ----------
b.----------
c. ----------
d.----------
e. ----------

-

2. Answer the following questions. **(2 x 5 = 10 marks)**

a. ----------
b. ----------

3. Answer the following questions. **(2 x 5 = 10 marks)**

a. ----------
b. ----------

4.Answer the following questions. **(2 x 5 = 10 marks)**

a. ----------
b. ----------

Internal Question Paper Pattern for 2 Credit Paper

PGK Mandal's
Haribhai V. Desai College of Arts, Science and Commerce (Autonomous)
Internal Exam - Semester
Department of Environmental Science

Subject Code: Subject Name

Date: **Max marks: 20** **Time:**

Answer the following questions. **(4 x 1 =4 marks)**

a. ----------
b. ----------
c. ----------
d. ----------

2. Answer the following questions. **(2 x 4 = 8 marks)**

a. ----------
b. ----------

3. Answer the following questions. **(2 x 4 = 8 marks)**

a. ----------
b. ----------

Structure of the Syllabus with Credit Framework

I. M. Sc. First year Environmental Sciences - Semester I Assessment of Credits

Components of Study	Course Code		Course Name	Credit	Sub Total
Core Compulsory Theory Papers	ENV-501-MJ-TH		Fundamentals of EnvironmentalBiology & Biodiversity	4	14
	ENV-502- MJ-TH		Fundamentals of Environmental Physics & Chemistry	4	
	ENV-503-MJ-TH		Environmental Statistics	2	
Core Compulsory Practical paper	ENV-504-MJ-PR		Practicals based on ENV-501, 502 and 503-MJ-TH	4	
Research Methodology Theory	ENV-531-RM-TH		Research Methodology	2	4
Research Methodology Practical	ENV-531-RM-PR		Research Methodology Practical	2	
Choice Based Optional Papers Elective/ Departmental Course **Any one group**	Group I	ENV-510-MJ-TH	Fundamentals of AtmosphericSciences	2	4
		ENV-511-MJ-TH	Fundamentals of Geo-Sciences	2	
	OR				
	Group II	ENV-512-MJ-TH	Sustainable Development	2	4
		ENV-513-MJ-TH	Environmental Education	2	
			Total		**22**

II. M. Sc. First year Environmental Sciences – Semester II Assessment of Credits

Course Type	Course Code		Course Name	Credit	Sub Total
Core Compulsory Theory Papers	ENV-551-MJ-TH		Water & Soil Pollution: Management & Mitigation	4	14
	ENV-552-MJ-TH		Air, Noise & Radiation Pollution: Management & Mitigation	4	
	ENV-553-MJ-TH		Environmental Law	2	
Core Compulsory Practical paper	ENV-554- MJ-PR		Practicals based on ENV-551, 552 and 553-MJ-TH	4	
Internship On job training	ENV-581-OJT		Internship /On Job training	4	4
Choice Based Optional Papers Elective / Departmental Course **Any one group**	Group I	ENV-560-MJ-TH	Water & Wastewater technology-I (Basic)	2	4
		ENV-561-MJ-TH	Water & Wastewater technology-II (Advanced)	2	
	OR				
	Group II	ENV-562-MJ-TH	Environmental Management	2	4
		ENV-563-MJ-TH	International Environmental Law	2	
			Total		**22**

III. M. Sc. Second year Environmental Sciences - Semester III Assessment of Credits

Components of Study	Course Code		Course Name	Credit	Sub Total
Core Compulsory Theory Papers	ENV-601-MJ-TH		Environmental Impact Assessment & Audit	4	14
	ENV-602-MJ-TH		Remote Sensing & GIS	4	
	ENV-603-MJ-TH		Watershed management	2	
Core Compulsory Practical paper	ENV-604-MJ-PR		Practical's based on ENV-601, 602 and 603-MJ-TH	4	
Research Project	ENV-631-RP-PR		Research Project-I	4	4
Choice Based Optional Papers Elective / Departmental Course	Group I	ENV-610 MJ-TH	Restoration ecology	2	4
		ENV-611 MJ-PR	Practical's based on ENV-610-MJ-TH	2	
Any one groups	**OR**				
	Group II	ENV-612-MJ-TH	Forestry & Wildlife Management	2	4
		ENV-613-MJ-PR	Practical's based on ENV-612-MJ-TH	2	
			Total		**22**

IV. M. Sc. Second year Environmental Sciences - Semester IV Assessment of Credits

Components of Study	Course Code		Course Name	Credit	Sub Total
Core Compulsory Theory Papers	ENV-651-MJ-TH		Solid & Hazardous Waste Management	4	12
	ENV-652-MJ-TH		Renewable and Non-renewable Energy	4	
Core Compulsory Practical paper	ENV-653-MJ-PR		Practicals based on ENV-651 and 652-MJ-TH	4	
Research Project	ENV-681-RP-PR		Research Project- II	6	6
Choice Based Optional Papers Elective / Departmental Course	Group I	ENV-660-MJ-TH	Environmental Toxicology Health & Safety	2	4
		ENV-661--MJ-TH	Environmental Policy & Climate Change	2	
	OR				
Any one groups	Group II	ENV-662-MJ-TH	Environmental Biotech & nanotech	2	4
		ENV-663-MJ-PR	Practical's related to ENV-662-MJ-TH	2	
			Total		**22**

Program Outcomes (PO)

PO1: Enhanced Environmental Literacy: To develop in-depth knowledge and integrate with existing knowledge to sensitize the people about global and local environmental issues.

PO2: Social Interaction- Development of scientific outlook not only with respect to science subjects but also in all aspects related to life. To inculcate a harmonious relationship between nature and human beings.

PO3: Critical Thinking- Cultivate critical thinking skills to effectively recognize, meticulously assess, and devise solutions for environmental challenges, leveraging fundamental tenets of ecological preservation.

PO4: Enhance Technical and Research Skills: cultivate skills by enabling the identification, formulation, and critical analysis of relevant research literature to address contemporary problems in the field.

PO5: Importance and Applications: Demonstrate understanding of the significance and applications of environmental science across academic, industrial, economic, and social spheres.

PO6: Environmental Experts: cultivates transdisciplinary expertise in environmental methodologies, empowering students for diverse environmental science careers.

PO7: Traditional Knowledge: To foster a culture of indigenous traditional knowledge application for sustainable future.

PO8: Environment and Sustainability- Critically analyze the impact of human activities on environmental systems and design solutions through integration of sustainability principles for promoting intergenerational equity and ecological integrity.

PO9: Career Perspectives: Undertake research and on field activities which develop problem solving abilities required for successful career in Environmental Science.

PO10: Development of Skills: Cultivate transferable skills, including effective communication, teamwork, project management, financial literacy and research proficiency encompassing experimental design, data analysis and evidence-based reasoning.

Program Specific Outcomes (PSO)

PSO1: Problem Solving: Cultivate the capacity to critically analyze and devise solutions to environmental challenges utilizing scientific principles and methodologies.

PSO2: Skill Enhancement: Foster a self-directed learning habit encompassing the ability to identify and acquire new knowledge and skills, including metacognitive skills, to navigate the dynamic workplace environment.

PSO3: Moral and ethical awareness/reasoning: Develop critical awareness of ethical dilemmas in their field, enabling them to analyze such issues from diverse viewpoints, articulate well-reasoned arguments, and integrate ethical principles into professional and personal conduct.

CourseCode: ENV-501-MJ-TH

Course Name: Fundamentals of Environmental Biology & Biodiversity

Credit: 4

Course Outcomes:

Course Outcome No.	Statements
CO.501.1	Outline of concept of Ecosystem, Ecology, Terrestrial and Aquatic biomes, Biodiversity
CO.501.2	Explain the components and functioning of Ecosystems, Discuss biogeochemical cycles
CO.501.3	Illustrate Various population dynamics and their impact on population growth
CO.501.4	Differentiate feeding, communication and reproductive behaviour of plants and animals
CO.501.5	Evaluate the role of different biological components in Ecological restoration and other environmental application.
CO.501.6	Derive energy flow in ecosystem, threats to biodiversity and plan for conservation of bio- resources

ENV-501-MJ-TH	ENVIRONMENTAL BIOLOGY & BIODIVERSITY (4 CREDITS)	No. of lectures in Clock Hours
1.	**Environmental Biology: Concepts and Scope:** ● Concept of Ecosystem; Biosphere as an ecosystem; its ecological processes and life support systems. ● Ecotone, and Role of biological processes in remedial measures and restoration.	**4**
2	**a) Fundamental Concepts of Ecology.** ● Ecology: Definition, development and scope. Ecology as an experimentalscience ● Ecosystems: concept, components and functioning. ● Energy Fixation (photosynthesis and chemosynthesis) and energy flowthrough food chains (grazing and detrital) and webs (include Y shapedenergy flow model). ● Ecological efficiencies and pyramids. Trophic levels ● Influence of environmental factors (including temperature, light, moisture, soil, nutrients) on organisms and their adaptations in response to them. **b) Ecology of Populations And Communities.** **(i) Population Ecology:**	**15**

	● Factors determining the abundance and distribution of a species ● Factors leading to the commonness, rarity and vulnerability of extinctionof a species. ● Population Dynamics: Patterns of survival, age distribution, dispersal andrates of change. Attributes of K- selected and r-selected species, Population Growth. **(ii) Community Ecology:** ● Competition, Exploitation (including herbivore, predation, parasitism), Mutualism (including commensalism, cooperation,symbiosis) ● Food webs and concepts of niche and keystone species. ● Nutrient cycling and retention: Biogeochemical cycles (Carbon, Nitrogen, Phosphorus), limiting factors and their tolerance. Succession, development, climax and stability of ecosystems (EXCLUDING Climax Theories), Cake and other ecological models, model of successions	
3	**Introduction To Plant And Animal Behaviour:** ● Ethology and socio-biology: General definition and concept ● Types of behaviour ● Feeding Behavior: Herbivores, Carnivores, Parasites, Saprophytes, Response of prey / plants (deterrence, defence, reward). ● Animal Architecture and use of tools ● Circadian and other rhythms. ● Migration, orientation, navigation, and homing. ● Communication (including visual, olfactory, tactile, auditory, chemical)Aggression, Territoriality, Altruism. ● Reproductive Behaviour: Courtship, Mating, Parental care, breedingsystems. ● Instinct and Learning: Genotype and phenotype behaviour. ● Insect and Vertebrate Societies, Associations	**12**
4	**Terrestrial and aquatic Biomes** ● Climatic and edaphic factors of terrestrial biomes. Heinrich Walter'sBiome Climate Diagrams ● Classification of land biomes with their soil, climate and vegetation characteristics. Their natural history, wildlife, geography and humaninfluences. ● Mountain Biome: Replication of latitudinal changes in the altitudes ofhigh mountains. ● Terrestrial biomes, ecosystem diversity, forest and vegetation types inIndia. ● Challenges and adaptations of life in aquatic biomes (freshwater: still andflowing, marine). ● Freshwater Biomes (Rivers, streams, lakes, ponds)	**10**

	• Marine Biomes (including mangroves, coral islands, kelp forests,saltwater marshes, seashores, estuaries) and their natural history Wetlands – definitions, types, ecological functions and resources.	
5.	**Environmental Microbial ecology:** • Classification of microbes and their metabolism and ecology • Micro-organisms and their association with man, animals and plants. • Role of microbes in bio-remedial processes, ecological restoration andother environmental applications • Environmental factors affecting microbes, their cultivation and growth. • Concept of bioindicators, bioindicators as plants, animals, bioindicatorsin manmade environment, role of bioindicator in pollution control. • Fundamentals of microbial nitrogen fixation and other pathways in terms of enzymology.	**8**
6.	**Concept of Carrying Capacity** Biotic and abiotic components of environment, concept of sustainability and carrying capacity, tragedy of commons, human population and food, water andenergy security, present status of environment and future scenarios.	**6**
7	**Introduction to Biodiversity** Biodiversity: An inventory of Global and Indian biological resources and theirpresent and potential uses; Values of biodiversity; threats to biodiversity;Strategy for conservation of bio-resources.	**5**
	Reference Books: 1. Environmental Science - Arms Karen 2. Principles of Environmental Science-Watt, K. E. F. (1973) McGraw-HillBook Company. 3. Environmental Science –Noble, B .J. Kormandy, E.J. (1981). The wayworld works, Prentice-Hall Inc., N .J. 4. Environmental Science-Turk A. , Turk J. Wittes J.T. and Wittes, R.E. 5. Environmental Issues: Measuring, Analyzing, Evaluating, Abel, Daniel C.McConnell, Robert L. Abel, Daniel C. Edi. 2 Prentice Hall Publication 6. Chaudhuri AB and Sarkar DD (2003) Megadiversity Conservation, Flora,Fauna and Medicinal Plants of India's Hotspots. Daya Publishing House,New Delhi. 7. Gary K Meffe and Ronald Carroll C (1994) Principles of Conservation Biology. Sinauer Associates Inc., Massachusetts.	

	8. Groombridge B (Ed.) (1992) Global Biodiversity Status of the EarthsLiving Resources. Chapman & Hall, London. 9. IUCN (1992) Global Biodiversity and Strategy. 10. Sharma PD (2000) Ecology and Environment. Rastogi Publications,Meerut, India. 11. Singh MP, Singh BS and Soma S. Dey (2004) Conservation of Biodiversity andNatural Resources. Daya Publishing House, New Delhi. Virchow D (1998) Conservation and Genetic Resources, Springer-Verlag,Berlin. 13. Singh B, (1992).Social Forestry for Rural Development, Anmol Publishers,New Delhi 14. Raymond F Dasmann(1984), Environmental Conservation, John Wiley. 15. Kato, M. The Biology of Biodiversity, (1999), Springer Verlag, Tokyo. 16. Kotwal, P.C. and S. Banerjee(2002) Biodiversity Conservation – InManaged forest and Protected areas. Agrobios, India. 17. Krishnamurthy, K.V. (2003)An Advanced Textbook on Biodiversity – 12. Principles andPractice. Oxford and IBH Publishing, New Delhi.	

Course Code: ENV-502-MJ-TH

Course Name: Fundamentals of Environmental Physics & Chemistry

Credit: 4

Course Outcomes:

Course Outcome No.	Statements
CO.502.1	Describe fluids, waves, optics, Nuclear Physics.
CO.502.2	Explain various techniques of element estimation, Fresnel and Fraunhofer diffraction
CO.502.3	Write application of Microscope, Crystallography, water waves, Atomic Physics, Spectroscopy.
CO.502.4	Compare between unsaturated and saturated hydrocarbon.
CO.502.5	Estimate DO, BOD, COD, Coagulation, Filtration of different water resources.
CO.502.6	Develop computational tools to model optical systems and simulate various experiments

ENV-502-MJ-TH	ENVIRONMENTAL PHYSICS AND CHEMISTRY (4CREDITS)	No. of lectures in Clock Hours
1	Estimation of various elements at major, minor, trace, rare level concentrations: choice of a technique, principle, merits and demerits of the techniques – neutron activation analysis, isotope dilution analysis, colorimetry, atomic absorption, spectroscopy, ICPAES, chromatography, HPLC, ion exchange chromatography, X-ray fluorescence, X-ray diffraction, Flame photometry, Polarography UV Spectrophotometer, Mass Spectrometry	**15**
2	Stoichiometry, Gibb's energy, Chemical Potential, Chemical equilibria, acid base reactions, solubility product, solubility of gases in water, the carbonate system, unsaturated and saturated hydrocarbon, radionuclides,Chemical bonding, chemical reactions and equations, Organic functional groups, classes of organic compounds. Free radical reactions, catalytic processes. Elemental cycles (C, H, N, S, O, P) and their environmental significance. Reversible and irreversible reactions of water, Cations and anions in water and their sources, Mass Balancing, concepts of DO, BOD, COD, sedimentation,coagulation, filtration, redox potential.	**10**

3	**Fluids:** Pressure, buoyancy, fluid flow, viscosity, surface tension. Applications to hydraulics, biology, biophysics, atmospheric physics, aerodynamics **Waves and oscillations: r**eflection, refraction, superposition, resonance, energy transport, absorption, Doppler effect. Applications towater waves,acoustics, seismology **Optics:** Geometrical optics including dispersion, lenses, mirrors,interference, diffraction, polarisation. Applications to microscopy, imaging, vision, crystallography **Quantum physics:** interaction of light with matter, x- rays. Application to atomic physics, lasers, and spectroscopy	**15**
4	**Nuclear physics:** Atomic nucleus, radioactive decay, half-life, ionising radiation, nuclear fission and fusion. Application to nuclear energy, radiation safety, nucleo-genesis, carbon dating. Effects of radiation on living tissue, background radiation, radon; units for radiation exposure; applications of nuclear technology, nuclear medicine, contaminant tracing,ion beam analysis **Thermodynamics:** Carnot cycle, refrigerators, heat engines, throttling process; Helmholtz and Gibbs Free energies, and phase transformations. Heat Energy And Kinetic Theory Heat and Temperature. Internal Energy,Specific Heat. Ideal gas Equation. Kinetictheory interpretation of pressure and temperature. Work, heat, and laws of thermodynamics. Adiabatic lapse rate. Radiant energy. **Optics:** Fourier optics, Fourier transforms in 1 and 2D, Dirac delta functionand comb, discrete Fourier transforms and the sampling theorem, convolution, cross and autocorrelation. Fresnel and Fraunhofer diffraction, Polarized light including production and control of polarization.	20
	Reference Books 1. Environmental Chemistry by A. K. De 2. Destruction of hazardous chemicals- G.Lunn, E.B.Sandome 3. Hazardous substances in chemical lab-G.D.MuMivir 4. Essentials of Nuclear Chemistry, H. J Arnikar, Wiley Eastern Limited,4th Edition.(1995)	

CourseCode: ENV-503-MJ-TH

Course Name: Environmental Statistics

Credit: 2

Course Outcomes:

Course Outcome No.	Statements
CO.503.1	Recall key statistical concepts and terms related to data analysis
CO.503.2	Explain measures of central tendency and dispersion in statistics
CO.503.3	Utilize inferential statistical tests to draw conclusions and make predictions based on environmental datasets
CO.503.4	Analyse environmental datasets to identify trends, patterns and correlations
CO.503.5	Evaluate the significance of statistical results in context of objective
CO.503.6	Carry statistical data analysis based on variables and samples

ENV-503-MJ-TH	ENVIRONMENTAL STATISTICS (2 Credits)	No. of lectures in Clock Hours
1.	**Foundation of environmental statistics –** Nature of environmental data: Survey based (empirical) and experimental data. Concepts of population and sample – Random variable and parameters of interest. Concepts of statistical inference, Simple random sampling for selection of sampling units for making observations.	3
2.	**Univariate data –** Frequency distribution and their properties (including Skewness and Kurtosis), Histogram, Frequency Curve and Ogive Curves. Measure of central tendancy: Mean, Median and Mode. Measure of Dispersion: Range, Variance, standard deviation and co-efficient of variation. Presentation of data: Summery statistics and graphical methods.	**4**
3	**Bivariate data -** Obtaining bivariate data by measuring two variables on a single sampling unit. Summary statistics for bivariate data: Mean, standard deviation and covariance, correlation coefficient. Scatter plot and its interpretation.	**4**

4	**Multivariate data –** Multivariate analysis, Regression Multivariate Analysis, PCA, Q-mode and R- Mode Factor analysis, Time-series data analysis, Moving averages, Wavelet analysis / Spectral analysis; Introduction to MATLAB	**5**
5	**Tests of Significance-** Chi- squared test: goodness of fit. Independence of attributes, T andFtests for significance	**2**
6	**Statistical models –** Distribution models: Normal distribution and its properties. Fitting of normal distribution. Calculation probabilities of different events for normal distribution. Standardization of data and approximation by normal distribution. Prediction models: linear and non- linear regressionmodels, fitting a regression line and parabolic curve, estimating regression coefficients. Calculation of fitted values and residuals.	**6**
7	**Statistical models in environmental science-** Population growth model, Catch model.	**3**
8	**Statistical Quality Control (SQC) Technique-** Meaning of Quality/SQC, Control Chart for variables (X-Bar and R-Charts)	**3**
	Reference books: 1. Barnett Vic (2004) Environmental Statistics: methodsand applications. 2. Ott, Wayne R. (1995) Environmental Statistics and data analysis. 3. Zar, Jerrold H. (1997) Biostatistical Analysis. Prentice Hall (India) 4. Nychka, Douglas and Piegorsch Walter W (1998) Case studies inenvironmental Statistics. 5. Manly Bryan F.J. (2001) Statistics for Environmental Science andManagement. 6. Walpole R. and Myem R. (1993) Statistics for engineers and scientists	

CourseCode: ENV-504-MJ-PR

Course Name: PRACTICALS RELATED TO ENV-501-MJ-TH, ENV-502-MJ-TH J & ENV-503-MJ-TH

Credit: 4

Course Outcomes:

ENV-504-MJ-PR	**PRACTICALS RELATED TO ENV-501-MJ-TH, ENV-502 MJ-TH & ENV-503-MJ-TH (4 Credits)**
	ENV 501 MJ-TH FUNDAMENTALS OF ENVIRONMENTAL BIOLOGY &BIODIVERSITY 1. Determining the rate of photosynthesis in an aquatic plant (hydrilla or elodea) 2. Estimation of chlorophyll content from given plant leaves 3. Vegetation studies by line and belt and quadrates methods 4. To study wetland bird diversity 5. Phytoplankton and zooplankton analysis from freshwater samples 6. Estimation of Productivity of lake 7. Preparation of media for microbial culture, Isolation and culturing ofmicrobes from soil / water samples, Gram Staining. 8. Bacterial growth curve 9. Enzyme analysis from soil samples
	ENV 502 MJ-TH FUNDAMENTALS OF ENVIRONMENTAL PHYSICSAND CHEMISTRY 1. Preparation of samples and analysis using Chromatography 2. Determination of Nitrogen, Phosphorus, Sulphur 3. Estimation of halides in water samples by Potentiometry 4. Preparation of samples and analysis using titration 5. Preparation of samples and analysis using Flame photometer 6. Preparation of samples and analysis using Spectrophotometer / UV Spectrophotometer

	ENV 503 MJ-TH Environmental Statistics Practicals 1. Grouping of data and preparation of frequency distribution. Histogram andfrequency polygon 2. Calculating mean, median and mode for grouped and ungrouped data 3. Calculating variance, standard deviation and coefficient of variationfor grouped and 4. ungrouped data 5. Fitting simple linear regression. Plotting scatter diagram and regression line 6. Computing correlation coefficient and testing its significance for groupedand ungrouped data 7. Comparison between means of two independent samples. Paired t-test 8. Analysis of variance: one way classification 9. Analysis of variance: two- way classification 10. Multivariate Analysis STATISTICA/ANOVA/SPSS Fitting statistical model of air pollution to data

CourseCode: ENV-531-RM-TH

Course Name: Research Methodology

Credit: 2

Course Outcomes:

Course Outcome No.	Statements
CO 1	Understand the concept of research and its terminology
CO 2	Understand types of research and approaches to research
CO 3	Demonstrate understanding of research methods and design for data collection
CO 4	Analyse and interpret the data
CO 5	Evaluate current trends in research and develop multidisciplinary approach
CO 6	Propose research proposal and represent data

ENV 531 RM-TH RM- Research Methodology Compulsory Theory Paper Total: 2 Credits

Workload: -15hrs/credit

(Total Workload: -2 credits x 15 hrs =30 hrs in semester)

Credit	Credit Title and Contents	Number of Lectures
I	1. History of research. 2. Research concept: Definition, Characteristics, Objectives, Utility 3. Types of Research: Descriptive vs. Analytical Research; Applied vs. Fundamental Research; Quantitative vs. Qualitative Research; Conceptual vs. Empirical Research 4. Problem Identification & Formulation: Formulating the research problem, Defining the research problem, Origin of the research problem 5. Literature Review: Purpose of the literature review, Types of information and sources, Primary and secondary sources 6. Research Objectives 7. Research design: Types of research design (descriptive research design, correlational research design, experimental research design, explanatory research design) 8. Research methods: Quantitative research, Qualitative research,	**15**

	Experimental research, and mixed methods approaches, Data Analysis and Interpretation, Sample collection and processing techniques (Water, soil, air and medical) 9. Citation: Methods, Bibliography, citation rules 10. Current trends in Research: Mono-disciplinary Research, Trans-disciplinary Research, Inter-disciplinary Research, Threats and Challenges to Good Research	
II	1. Data Presentation: Presentation skills, formal scientific presentation skills; Preparing power point presentation, Presenting the work, Scientific poster preparation 2. Research report writing: Purpose of the writing, Types and Formats of scientific reports, scientific writing skills, Significance of communicating science, ethical issues, Copy rights and plagiarism, Components of a research paper 3. Preparation of Project Proposal – Time frame and work plan – Budget and Justification	**15**

CourseCode: ENV-531- RM-PR

Course Name: Research Methodology Practical

Credit: 2

Course Outcomes:

ENV 531 RM-PR Research Methodology Compulsory Practical PaperTotal: 2 Credits Workload: 30hrs/credit (Total Workload: 2 credits x 30 hrs =60 hrs in semester)		
Credit	**Title and Contents**	**Number ofhours**
	Seminar presentations, group activities, and scientific writing sessions based on above theory course. These willinclude but not limited to- 1. Use of search engines for scientific data mining 2. Use of reference management tools 3. Preparing power point presentation 4. Statistical data analysis using software 5. Presenting a research article 6. Writing an abstract for a research paper 7. Preparing a graphical abstract using software 8. Writing a concept note for research project 9. Scientific poster preparation & presentation 10. Writing a scientific news article or a science blog 11. Preparing and scientoon 12. Participating in group discussions, conferences, symposia etc.	**60**

Course Code: ENV-510- MJ- TH (Group I)

Course Name: Fundamentals of AtmosphericSciences

Credit: 2

Course Outcomes:

Course Outcome No.	Statements
CO 1	Describe the basics of evolution of earth, its process, hydrology and soil.
CO 2	Discuss the correlation between various process and earths stability
CO 3	Examine the impact and changes caused by over utilization of earths resources and pollution
CO 4	Investigate the root causes of imbalances in earth process
CO 5	Measure the present conditions based on study of environmental parameters
CO 6	Propose a base plan for achieving environmental stability through monitoring parameters

ENV 510 MJ-TH	FUNDAMENTALS OF ATMOSPHERIC SCIENCES (2 Credits)	No. of lectures in Clock Hours
1	• Evolution, Composition and Structure; Elements of weather and climate; Weather Parameters (temperature, wind pressure, relative humidity, rainfall); Climatology of weather parameters; Long- and Short-term climatic effects • Insolation; The energy system and its balance; Flux of solar system in thebiosphere; Earth's radiation budget; Net radiation and latitudinal heat balance; Green House Effect and Human influence on radiation balance. • Atmospheric pressure, measurements & Distribution; Pressure & Wind Belts; local winds; Geostrophic & gradient winds; Air masses, Classification and modifications of air masses. Fronts, Classification of fronts. Atmospheric moisture- Condensation; Forms of precipitation; Cloud Classification; Indian Monsoon; Inter-tropical Convergence Zone (ITCZ); • Walker Circulation: El Nino- La Nina • Atmospheric Stability & Instability; Dry and moist adiabatic lapse rate; • Environmental lapse rate, plume behaviour • Environmental Meteorology - Atmospheric chemical transport	**20**

	models; emission inventory- aerosol and gas pollutants; National Air QualityStandards and Indices; Dry and wet deposition fluxes of gas and aerosol pollutants; Intercontinental and hemispheric transport of air pollutants	
2.	**Ocean Science:** ● Ocean Basins and Physical structure of ocean floor; Oceanicenvironments ● Vertical stratification of water column (Temperature, Pressure,Salinity, pH, Oxygen, CO2, Nutrients) ● Waves, Tides, Currents, Tsunamis; Importance of winds & Hadley's Cell;Coriolis Effect; Geostrophic Currents; Ekman Spiral; Upwelling ● & Productivity; Surface; Thermohaline and Bottom water circulation	**8**
3	**Earth Resources:** Occurrence, exploitation and environmental impacts Coal, Hydrocarbons and mineral resources.	**2**

CourseCode: ENV-511- MJ –TH (Group I)

Course Name: Fundamentals of Geo-Sciences

Credit: 2

Course Outcomes:

Course Outcome No.	Statements
CO 1	Describe the basics of atmosphere and oceans and its process
CO 2	Discuss the correlation between various ocean process and atmosphere stability
CO 3	Examine the impact and changes caused by over utilization of ocean resources and pollution
CO 4	Investigate the root causes of imbalances in atmosphere and oceans
CO 5	Measure the present conditions based on study of environmental parameters
CO 6	Propose a base plan for achieving environmental stability through monitoring parameters

ENV 511 MJ-TH	FUNDAMENTALS OF GEO SCIENCES (2 Credits)	No. of lectures in Clock Hours
1.	**Earth: Origin, Structure, Dynamics & Composition** ● **Origin:** Origin of Earth & its spheres (Lithosphere,Biosphere, Hydrosphere, Atmosphere) ● **Structure:** Internal Structure of Earth - Core, Mantle and Crust; Thermal,Magnetic & Gravitation Fields of the Earth ● **Dynamics:** Concepts of Plate Tectonics & Sea Floor Spreading, Mountainbuilding (folding and faulting), Earthquakes, Volcanism ● Composition: Igneous, Sedimentary & Metamorphic Rocks; Processes and formation; Characteristics of major Rocks andMinerals.	**9**
2.	**SURFACE PROCESSES & LANDFORMS** ● Processes and agents of weathering, erosion, transportation anddeposition; Cycles of erosion- Davis and Penck Models ● Mass-wasting; ● Erosional and depositional landforms: Glacial, Aeolian, Fluvial, Coastal,shallow marine and deep marine. ● Concept of Engineering & Urban Geology	**6**

3.	**Soil:** Genesis of Soil; Soil Profile; Soil texture, structure; Bio-, Physico- Chemical properties of soil; Soil Classification; Soil types w.r.t. genesis;Fertility; Lateritization; Land use and Land capability classification; Water-logging, salinization, desertification and degradation of soil.	**7**
4.	**Hydrology:** ● Concept of Hydrology & Hydrogeology ● Hydrological Cycle (Precipitation, Infiltration, Surface Run off, Evapo-transpiration) ● Surface & Groundwater Resources; ● Vertical distribution of groundwater: Types of Aquifers & Springs; Hydrological properties of rocks: Darcy's Law, Storativity, HydraulicConductivity, Transmissivity, ● Concept of Drainage Basin and Watershed.	**8**

CourseCode: ENV-512-MJ-TH (GroupII)

Course Name: Sustainable Development

Credit: 2

Course Outcomes:

Course Outcome No.	Statements
CO 1	Define and List down the sustainable development goals.
CO 2	Discussion of current and future challenges to achieve sustainable development.
CO 3	Demonstrate how renewable energy resources contribute to achieving SDG's.
CO 4	Distinguish between the social, environmental and economic need of present and future generation and Investigate the effectiveness of government policies.
CO 5	Evaluate the role of local communities in driving sustainable development in rural area and evaluate the impact of sustainable agricultural practices on food security.
CO 6	Design a global strategy to achieve the Sustainable Development Goals by 2030

ENV-507-MJ-TH	**SUSTAINABLE DEVELOPMENT (2 Credits)**	**No. of lectures in Clock Hours 30**
1	**Sustainable development** Impact of development of environment, sustainability, World Commission on Environment and Development, definitions of sustainability and sustainable development, need for sustainable development	**6**
2	**Ecosystem & Sustainability:** Fundamentals of ecology - types of ecosystems & interrelationships, factors influencing sustainability of ecosystems, ecosystem restoration - developmental needs. Introduction to sustainability & its factors, requirements for sustainability: food security and agriculture, renewable resources - water and energy, non-renewable resources, factors and trade-offs, sustainability conflicts	**6**
3	**Dimensions to Sustainable Development** - society, environment, culture and economy; current challenges - natural, political, socioeconomic imbalance; sustainable development initiatives and	**6**

	policies of various countries : global, regional, national, local; needs of present and future generation - political, economic, environmental.	
4	**Gauging Sustainable Development** - Sustainability and development indicators and SDGs, UN's outlook of sustainable development and efforts, UN SDGs - structure, governance and partnerships; communities / society: ensuring resilience and primary needs in society; biosphere: development within planetary boundaries; strengthening institutions for sustainability; shaping a sustainable economy.	**6**
5	**Case Studies & Projects on Urban and Rural Sustainable Development (Indian perspectives) –** Sustainable cities, smart infrastructure, resilience, Village resources (broad perspectives); current challenges and thematic areas; village social hierarchy; village economy; needs of present and future generation; conflicts - sustainability and rural culture & tradition; road to achieving sustainable development goals - bridging conflicts and way forward.	**6**
	Suggested reading • Franco, I.B. and Tracey, J. (2019), "Community capacity-building for sustainable development: Effectively striving towards achieving local community sustainability targets", International Journal of Sustainability in Higher Education, Vol. 20 No. 4, pp. 691-725 • Our Common Journey: A Transition Toward Sustainability. National Academy Press, Washington D.C. Soubbotina, T. P. 2004. • Elliott, Jennifer. 2012. An Introduction to Sustainable Development. 4th Ed. Routledge, London. • Rogers, Peter P., Kazi F. Jalal, and John A. Boyd. "An introduction to sustainable development." (2012). • Sachs, J. D. 2015. The Age of Sustainable Development. Columbia University Press, New York. • Soubbotina, Tatyana P. 2004. Beyond Economic Growth: An Introduction to Sustainable Development. WBI learning resources series. Washington DC ; World Bank.	

CourseCode: ENV-513- MJ-TH (Group II)

Course Name: Environmental Education

Credit: 2

Course Outcomes:

Course Outcome No.	Statements
CO 1	Define sustainable development and describe the guiding principles of environmental education
CO 2	Explain the role of environmental education in promoting sustainable practices
CO 3	Demonstrate the importance of integrating environmental education and sustainability principles into school curriculum.
CO 4	Appraise the role of eco clubs and project-based education in enhancing students understanding of environmental aspects.
CO 5	Evaluate how well current environmental education policies addresses the environmental conservation and natural resource management
CO 6	Propose an outdoor education program and project-based learning activity that encourages the sustainable practices among students

ENV 513 MJ-TH	Environmental Education	No. of lectures in Clock Hours 30
1	**Introduction to Environmental Education (EE) and Education for Sustainable Development (ESD)** Importance of EE and ESD as essential tool for achieving sustainable development. Evolution of the concepts of EE and ESD at the international level, Agenda 21 and Earth Charter; Traditional and community-based approaches of teaching and learning; Guiding Principles of Environmental Education.	**6**
2	EE in Formal Education Current policies and status of EE and ESD in Indian school systems and other countries. Evolution of EE in Indian school systems, the importance to Environment in India's National Policy on Education, EE in National Curriculum Framework; Quality Education and ESD; extra-curricular approaches; the whole-school, whole-systems approach: textbooks and EE; school infrastructure and habitat; eco-clubs; project-based learning EE at college/ university level. Teacher orientation for EE and ESD	**6**
3	**ESD and Communication, Education and Public Awareness (CEPA)**	**6**

	Policies and approaches to public awareness. EE/ ESD/ CEPA as elements of multilateral environmental agreements, national programmes, and civil society efforts in environmental conservation, natural resource management, health and sanitation, waste reduction and management, pollution abatement, consumption and lifestyles.	
4	**Educator Competence** The role of the educator and facilitator. Understanding advocacy, communication, facilitation, collaborative and action learning. Framework of competence for Education for Sustainable Development.	**6**
5	**Teaching-Learning Approaches** Introduction to teaching-learning processes and techniques in the context of EE and ESD; developing and using different approaches. Roles and use of traditional and new media. Experiencing nature/ nature camps. Communication campaigns, mass media. Deliberative and participatory techniques. Techniques to enhance systems thinking, critical thinking, values clarification, empathy. Evaluation of EE and ESD programmes	**6**
	Readings and references Tbilisi to Ahmedabad – Centre for Environment Education Green Teacher - Centre for Environment Education Green Action Guide - Centre for Environment Education UNECE Strategy for Education for Sustainable Development National Curriculum Framework – NCERT ESD Toolkit – UNESCO Engaging People in Sustainability (IUCN, Gland, Switzerland) - Tilbury, D. and Wortman, D. (2004) Power: A practical guide for facilitating social change - Raji Hunjan and Jethro Pettit Wals, A. (ed.) (2007). Social learning towards a sustainable world. Wagening: Academic Publisher Ison, R. (2010) Systems Practice: How to Act in a Climate Change World**.** Dordrecht: Springer.	

CourseCode: ENV-551- MJ-TH
Course Name: Water & Soil Pollution: Management & Mitigation
Credit: 4
Course Outcomes:

Course Outcome No.	Statements
CO 1	Recall the sources and pathways of water and soil pollution
CO 2	Explain the environmental and socioeconomic impacts of water and soil pollution
CO 3	Implement sampling and analysis techniques to assess water and soil quality.
CO 4	Analyze the effectiveness of different pollution control techniques and management strategies.
CO 5	Evaluate the sustainability of remediation techniques and long-term impacts on ecosystems
CO 6	Conduct a public awareness campaign to educate communities about the importance of water and soil conservation and pollution prevention

ENV-551-MJ-TH	Water and Soil Pollution: Management & Mitigation (4 Credits)	No. of lectures in Clock Hours
1.	**Freshwater Pollution** • Types and sources, Inorganic and organic pollutants responsible for water pollution: Biological pollutants; Pesticides; Radioactive pollutants, etc. • effluent standards, Drinking water standards, Characteristics of Domestic waste, Characteristics of Agricultural waste. • Consequences of water pollution: Effects on health, on biosphere and on economy. • Remedial measures of Freshwater pollution. • Case studies based on freshwater remediation using traditional and moderntechnology.	**16**

2.	**Groundwater Pollution** • Sources, groundwater contamination zones, groundwater remediation *in situ* and *ex situ* techniques; • bioremediation strategies of groundwater using bio-venting, bio- sparging,bio- slurping, permeable reactive barriers; • groundwater monitoring using Piezometer, slug and pumping tests; • Darcy's Law for estimation of hydraulic parameters, Numerical simulationfor aquifer yield prediction, Artificial recharge and induced infiltration, Land subsidence; • Coastal aquifers & Sea water intrusion • Environmental regulatory bodies preventing groundwater pollution; • Case studies-based insight in to groundwater remediation techniques.	**16**
3.	**Marine Water Pollution:** • Sources, types and consequences; • Ballast water pollution • pollution due to off shore drilling, deep mining and oil extraction and othersources; • prevention methods, control measures using bioremediation (bio- surfactants, microcosms), physical (booms, skimmers, absorbents etc) and chemical methods (dispersants, detergents etc). • Case studies-based analysis of marine water pollution and prevention strategies.	**12**
4	**Soil Pollution and Control** • Types, Effects and sources and consequences. • Mechanism of interaction of waste with soil. • Transport processes — biological process-microbial transformation of heavy metals. • Specifications for disposal of sewage and effluent on land for irrigation and groundwater recharge. • Methodology of wastewater disposal on land in India. • Impacts of usage of land for solid waste disposal both municipal solid waste and industrial solidwastes (fly ash from thermal power station, lime sludge from pulp and papermills). • Disposal of hazardous solid waste (heavy metals, toxic organic compounds) on land and its impact on soil pollution. • Deterioration of soil due to mining activities • Case study of restoration of land due to a disposal of fly ash, dumping overburden and tailing in iron ore extraction.	**16**

	Reference Books: • Groundwater In the Environment: An Introduction, Paul L Younger2014, ISBN:978-265-4636-7 • Groundwater Hydrology, Bhagu R Chahar, McGraw Hill • EducationEnvironmental Chemistry, B. K. Sharma • Environmental Chemistry and Pollution Control, S. S. • DaraEnvironmental Pollution, N. Manivasakam • Environmental Chemistry, Samir K. Banerji	

CourseCode: ENV-552- MJ-TH
Course Name: Air, Noise & Radiation Pollution:Management & Mitigation
Credit: 4
Course Outcomes:

Course Outcome No.	Statements
CO 1	Describe Air, Noise and Radiation Pollution
CO 2	Summarise the effects on Air, Noise and Radiation Pollution
CO 3	Demonstrate the working of Air pollution control by fuel selection.
CO 4	Investigation and assessment of impact of Air and Noise
CO 5	Measure Noise pollution in all four zones and also assess Air Quality of the indoor and outdoor.
CO 6	Compose a plan to reduce Air, Noise and Radiation Pollution

ENV-552-MJ-TH	Air, Noise & Radiation Pollution: Management & Mitigation	No. of lectures in Clock Hours
1.	**Air Pollution: Causes and Effects:** • Definition, Composition of air, • Classification of air pollution, Sources, • Effect of gaseous and particulate pollutants on animals, plant and humanhealth, • Economic effects of air pollutants, Vehicular Pollution, Industrial Pollution.	4
2.	**Air Pollution Meteorology & Chemistry** • Wind as a factor, • Temperature structure, • The role of atmospheric stability, • Dispersion of air pollutants. • Chemical Principles and Troposphere and Stratospheric Ozone Chemistry: Ozone formation & destruction, Polar Stratospheric Clouds (PSPs).	8
3.	**Air Quality Analysis** • Air monitoring instruments and techniques: SOX, NOX, O3, C6H6,Pb, CO, H_2S, NH_3, HC, Fluoride, SPM, RPM	8

4.	**Air Pollution Control Technology:** • Equipment's and Basic Operating Principle; • Control of air pollution by fuel selection, • principle and working of – cyclones, scrubbers, settling chambers and electrostatic precipitators. • Control of gaseous pollutants: absorption, adsorption, condensation, vapor incineration. • Equipment for control of air pollution – Cyclones, Wet scrubbers, Electrostatic precipitators, fabric filters, absorption.	8
5.	**Air Quality Management: Policy and Institutional Framework** • Ambient Air Protection Policy, Air Quality Norms, Regulation of Emissions from Stationary & Non-Stationary Sources. • Public Informing and Participation in Decision Making Process, Planning and Implementation of Ambient Air Protection Measures. • Strategies for Air Pollution Control - Control of air pollution by fuel selection and utilization, by process modification or equipment, by site selection and zoning.	8
6.	**Air Pollution Episodes:** Case Studies	2
7.	**Noise Pollution & Control** • Introduction to noise and vibrations, • physics of sound and hearing, • Noise pollution, sources and effects. • Noise control at source: Source path receiver concept, control bydesign, control by redress • Noise control in the transmission path: Acoustical separation, physicalbarriers, Isolators and Silencers • Protecting the receiver: personal protection device	6
8.	**Noise Monitoring and Impact Criteria** • Noise measuring techniques, national standard for noise, • noise monitoring methods, A-weighted Sound Level: The Basic Noise Unit; Maximum Sound Level (Lmax) During a Single Noise Event; • Sound Exposure Level (SEL): Exposure from a Single Noise Event HourlyEquivalent Sound Level (Leq (h)); Day-Night Sound Level (Ldn): 24- Hour Exposure from All Events; A Noise-Exposure Analogy for Leq andLdn	6

	• Investigation and assessment of impact of noise, Considerations in applying the Noise Impact Criteria; • Mitigation Policy Consideration;Determining the Need for Noise Mitigation.	
9.	**Radiation Pollution** • Radioactivity – types and measurement. Detection of nuclear radiations– G. M. counter, scintillation counter, semi-conductor detector. • Radiation hazards and safety – natural and manmade. • Types of radiations. Internal and external radiation hazards, safe handling methods, personal dosimeter, reactor safety. Interaction of radiation withmatter. • Units of measurements, half-life period, radiation dose measurement. • Biological effects and health hazards associated withradiation. Interaction of radiations with biological cells, somatic and genetic effects. • Classification of radio-active wastes – gas, solid, liquid. • Control measures – treatment and disposal of radio-active waste, generation of waste from various sources. • ICRP recommendations. AERB classification, maximum permissible dose. • Three miles and Chernobyl accidents.	10
	Reference Books • Fundamentals of Air Pollution – Daniel A. Vallero • Air Pollution: Health and Environmental Impacts – L.T Molina & B.R Gurjar • Advanced Air and Noise pollution Control – L.K Wang & N.C Pereira • Textbook of Noise Pollution & Its Control – S.C. Bhatia Environmental Chemistry - A.K. De • Environmental Chemistry – B.K. Sharma	

CourseCode: ENV-553-MJ-TH
Course Name: Environmental Law
Credit: 2
Course Outcomes:

Course Outcome No.	Statements
CO 1	Recall the legal provisions for environment
CO 2	Associate the importance of environment in legal systems National and International for sustainable development
CO 3	Demonstrate the implications of environmental offence with respect to legal provisions
CO 4	Inspect the mandatory procedure to followed with respect to provisions
CO 5	Argue and defend the sustainable approach and ethical dilemma governing the legal process to be adapted
CO 6	Design and develop polices

ENV-553-MJ-TH	**ENVIRONMENTAL LAW (2 CREDITS)**	**No. of lectures in Clock Hours**
1.	Introduction to Law and Policy- basic concept of Law and Policy(Importance and difference)	1
2.	International Conferences impacting Indian legal system such as Stockholm conference, Rio conference, Rio+5,Rio+10.	1
3.	Environmental Policies in the Indian Constitution - Role of constitution in environment protection, Fundamental rights and duties, Article 48A,51A (g), 58A, etc.	1

4.	Important Environmental Laws in India • The Wildlife (Protection) Act, 1972 • The Water (Prevention and Control of Pollution) Act, 1974 • The Air (Prevention and Control of Pollution) Act, 1981 • The Environment (Protection) Act, 1986 and importantnotifications issued under this Act • Coastal Regulation Zone Notification 2018 • The Energy Conservation Act, 2001 • Biological Diversity Act 2002 • Scheduled Tribes and Other Traditional Forest Dwellers(Recognition of Forest Rights) Act, 2006 (FRA) • The National Green Tribunal Act, 2010 • Compensatory Afforestation Fund Act, 2016 • The Forest (Conservation) Act, 1980	15
5.	Rules and Regulations (As amended) • Hazardous Waste Rules • Solid Waste Management Rule • Biomedical Waste Rules • Batteries Rules • E- waste rules • Plastic Waste Management Rules (Extended ProducerResponsibility (EPR) • Construction and Demolition waste Rules • Concept of Eco sensitive zones,	08
6.	International Environmental Laws and Policies • UNFCCC, Paris climate accord or Paris climate agreement 2015 • Kyoto Protocol • Convention on Biodiversity • International Solar Alliance • CITES • Ramsar Convention • Basel Convention • MARPOL • Cartagena Protocol on Bio-safety • AGENDA 21 Others	04

	Reference Books: 1. T S Doabia. 2017. Environmental and Pollution Laws In India.3rd Edition. Publisher: Lexis Nexis 2. P. Leelakrishnan. 2016. Environmental Law in India. 4thedition. Publisher: Lexis Nexis. 3. S. K. Mohanty. 2009. Environment and Pollution Laws.Publisher: Universal. 4. P. Leelakrishnan. 2006. Environmental Law Case Book. 2ndedition. Publisher: Lexis Nexis. 5. Divan Shyam and Rosencranz Armin. 2002. Environmental Law and Policy in India: Cases, Material & Statutes. Publisher: Oxford.	

CourseCode: ENV-560- MJ-TH (Group I)
Course Name: Water & Wastewater technology-I(Basic)
Credit: 2
Course Outcomes:

Course Outcome No.	Statements
CO 1	Describe population forecasting methods, state different water quality standards.
CO 2	Explain the application of various units of Water and Waste Water Plant.
CO 3	Apply Various advanced treatment methods in appropriate unit operations. .
CO 4	Compare various techniques for improvement in quality of water and Waste Water
CO 5	Estimate for designing of each operational units in Water and Waste Water Treatment Plant. Selection of appropriate unit operation for treatment.
CO 6	Create flow chart of Water Treatment and Waste Water plant. Construct and design Water Treatment and Waste Water plant

ENV-560-MJ-TH	**WATER & WASTE WATER TECHNOLOGY-I (BASIC) (2 CREDITS)**	**No. of lectures in Clock Hours**
1	• Quantity of water - Water Requirements for domestic consumption. Population forecasting by the following method; Demographic method, Arithmetical progression method, Geometrical progression method,Logistic methods, Graphical projection method, Final prediction. Variation in quantity of water and waste water, Factors affecting rate of demand. • Quality of water required for – Domestic, Institutional (Schools, Hostels, Hospitals), Firefighting, Commercial (Shopping complex, Hotels, Restaurant), Industrial (Dairy, Sugar, Pulp and Paper, etc.). Specific requirement at pilgrimage place and recreation activities Quality parameters for water analysis, methods for analysis.	**8**

2	• Impact of future growth and development and change in quality of life on water requirement. • Need of water quality standards for domestic &industrial purpose. Specifications for drinking water (physical, chemical &bacteriological) by Bureau of Indian Standards & World Health Organization. Packaged drinking water. Coliform bacteria as indicator organisms, Tests for the coliform group (MPN Method), growth kinetics.	**6**
3	• Water Treatment – Principle, Application & Designing of following unit operation water treatment. • a. Collection & pumping; b. Aeration; c. Flocculation; d. Sedimentation; e. Filtration; f. Disinfection; g. water softening	10
4	Wastewater technology – • Impact of Future growth & development & change in quality of life on sewage quality & quantity. • (Physical, Chemical and Biological Treatment), different models of aerobic and anaerobic digestion by combination of attached & suspended growth • Role of microorganisms, Kinds of Microorganisms, Pathogenic microbes, indicator microbes, enumeration of microbes, Water borne diseases, • Importance of public health perspectives, socioeconomic impacts, Types of waterborne diseases (Protozoan, Algal, Fungal, Bacterial, and Viral diseases), prophylactic measures	6
	Reference Books: 1. Water Supply and Sanitary Engineering –G.S.Birdie and J.S.Birdie 2. Water Supply Engineering –Dr. P.N.Modi 3. Water Supply and Wastewater Engineering –Dr. B.S.N.Raju 4. Water Supply Engineering –B.C. Punmia 5. Water Supply Engineering –Hussain 6. Water Supply Engineering –Chatterjee 7. Water supply and sanitary engineering - Rangwala	

CourseCode: ENV-561- MJ-TH (Group I)

Course Name: Water & Wastewater technology-II (Advanced)

Credit: 2

Course Outcomes:

ENV-561-MJ-TH	WATER & WASTE WATER TECHNOLOGY-II (ADVANCED) (2CREDITS)	No. of lectures in Clock Hours
1	• Specifications of treated wastewater for disposal into surface water, on land & in marine waters after treatment. • Self-purification of water bodies	4
2	• Advanced treatment methods: a. Demineralization; b. Ultra-filtration; c. Reverse osmosis; d. Color & odor removal by activated carbon; e. Iron removal; f. Nitrification and denitrification • Selection of appropriate unit operations for the treatment and flow chart of water treatment plant	6
3	• Wastewater engineering - Primary, secondary and Tertiary treatment process. • Principle and designing of following Unit Operations in wastewater treatment: Collection system - Methods of collection, conservancy systems, collection system, water carriage system, sewerage system. Screen chamber, Grit chamber, Oil & grease removal, Aeration and sedimentation, Stabilization Pond, Aerated lagoon, activated sludgeprocess, trickling filter, Rotating biological contactors Anaerobic digestion processes, fluidized bed reactor, UASB Treatment and Disposal of sludge (composting, sludge cakes, sludge digestion, energy recovery) Special treatments like septic tanks, soak pits.	15
4	• Industrial Wastewater-Selection of appropriate unit operations for thetreatment and flow chart of wastewater treatment plant for a. Dairy; b. Pulp & Paper; c. Galvanizing, etc.	5
	Reference Books: • Waste water engineering – Metcalf & Eddy • Elements of Environmental Engineering –K.N. Duggal • Environmental Biotechnology-T Srinivas (New Age Publications) • Environmental Engineering - Peavy, Rowe, Tchenobolus • Water supply and sanitary engineering - Rangwala	

CourseCode: ENV-562- MJ-TH (Group II)

Course Name: Environmental Management

Credit: 2

Course Outcomes:

Course Outcome No.	Statements
CO 1	Outline the fundamentals, tools and standards for environmental management
CO 2	Explain the environmental management systems
CO 3	Demonstrate Life Cycle Analysis
CO 4	Appraise environmental designs
CO 5	Evaluate application of environmental management systems in economy

ENV 562MJ-TH	ENVIRONMENTAL MANAGEMENT (2 CREDITS)	No. of lectures in Clock Hours
1.	• Environmental Management, role in sustainable development, Fundamentals of environmental management, • Tools of environmental management, international standards in environmental management. • Background and development of the ISO 14000 series of standards. EMAS- European Union	5
2.	• Environmental Management Systems Definition and scope, • Goals and purposes of EMS, Planning, • Implementation, Review and Improvement (Plan, do, check, act model), • Benefits of EMS- Environmental benefits, economic benefits, Costs associated with EMS	5
3	• Life Cycle Analysis Definition, Goals and purpose, • Stages in product LCA,Procedure for LCA- defining the goal and scope, analyzing the inventory, • Assessing the environmental impact and evaluating the environmental profiles, LCA uses and tools, Variants of LCA- cradle to grave, cradle to gate, cradle to cradle, gate to gate, well to wheel, • Benefits and limitations of conducting LCA	8

4.	• Environmental design Principles, benefits, motivation, ED for manufactured products, • ED for buildings ED for developmental planning	6
5	• Circular Economy vs linear economy, rationale for why we need to transform to a Circular Economy, closed loop systems, • Economic and social value, role of governments and networks and how policies and sharing best practices can enable the circular economy	6
	References/texts • Vijay Kulkarni and T V Ramchandra. "Environmental management"Capital Publishing • Bala Krishnamoorthy. "Environmental Management: text & case studies"PIH learning • ISO14001 standard for EMS	

Course Code: ENV-563- MJ-TH (Group II)

Course Name: International Environmental Law

Credit: 2

Course Outcomes:

Course Outcome No.	Statements
CO 1	Outline International legal provisions and conferences
CO 2	Review International environmental principles and concepts, declarations, conventions and treaties.
CO 3	Inspect the mandatory procedure to followed with respect to provisions
CO 4	Summarize the legal procedures and approaches
CO 5	Design and develop polices with reference to international regulations

ENV-563- MJ-TH	INTERNATIONAL ENVIRONMENTAL LAW (2 CREDITS)	No. of lectures in Clock Hours
1.	• Development of international environmental law, nature and scope of keyinternational environmental law principles and rights (substantive and procedural) • U.N. Conference on Human Environment, 1972 – Stockholm Principles, Establishment of Environmental Institutions like UNEP, World Charter for Nature	5
2.	• Rio conference, Rio declaration, conventions and treaties signed at Rio Agenda 21, Millennium development goal (now sustainable development goals) • Role of international institutions and actors involved in InternationalEnvironment Law. • Some basic environmental principles and concepts developed by the international legal system like Prevention, • Sustainable development, Polluters pay/liability, • Precautionary principles, • Inter- generational equity which are integral part of National Environmental Policy (2006) of India	10

3	• Laws of climate change • Montreal Protocol • United Nations Framework Convention on Climate Change (UNFCCC) • The Kyoto Protocol, • Paris Agreement (2015) • International Solar Alliance	6
4.	• Laws on hazardous wastes • Basel Convention on Transboundary Movement of Hazardous Waste, • Rotterdam Convention on Prior Informed Consent, • Protocol on liability and compensation for damage resulting from trans boundary movements of hazardous wastes and their disposal, 1999. • MARPOL	3
5	**Laws on Biodiversity Protection** Important provisions under the • Convention on Biological Diversity (CBD) • CITES • Ramsar Convention • Cartagena Protocol on Bio-safety	6

To be implemented from Academic Year: 2025-26

Faculty	**Science**
Program	**Environmental Science**
Class	**M. Sc. II**

Course Code: ENV-601-MJ-TH

Course Name: Environmental Impact Assessment & Audit

Credit: 4

Course Outcomes:

Course Outcome No.	Statements
CO.601.1	Describe EIA, History of EIA, EIA Policy and Legislation and environmental audit
CO.601.2	Explain the process of EIA, EIA Policy and Legislation in India
CO.601.3	Demonstrate methodology of Baseline Environmental data collection and procedure of public hearing
CO.601.4	Inspect the Environmental Clearance
CO.601.5	Assess pollution by conducting audits
CO.601.6	Devise a Environmental Management Plan

ENV-601-MJ-TH	ENVIRONMENTAL IMPACT ASSESSMENT & AUDIT (4 CREDITS)	Lectures 60
1.	**Introduction to EIA** i. Concept of EIA within the frameworks of sustainable development ii. History of EIA iii. EIA – Definition, and Objective/purpose iv. Reasons for using EIA v. Core Values of EIA – Comprehensive study, sustainability integrity and utility vi. The Eight Guiding Principles of EIA. vii. Operating principles of EIA viii. Benefits and flaws of EIA	4

	ix. Misconception about EIA and counter arguments that 1) it is expensive and delays projects 2). It is just an add-on and occurs too late to do any good 3). It is too complex and doesn't produce useful results 4). EIA will be misused to stop development. 5). We are too poor to afford EIA x. Key elements of EIA: Screening, scoping identifying and evaluating impacts, mitigations	
2.	**Law, Policy and Institutional Arrangements** i. EIA Policy and Legislation - Linkage between EIA and International Conventions ii. EIA in International (World bank, UNDP, Asian Development Bank, etc.) and National Development Institutions iii. EIA Policy and Legislation in India iv. Prevailing EIA notification and important provisions under the same e.g. a) terms of reference, b) categorization of projects, c) public hearing/consultation procedure, d) validity of terms of reference, environmental monitoring, public hearing, environmental clearance, etc.	6
3.	**EIA processes** i. Screening Procedure (as per prevailing EIA notification) including project lists for screening ii. Other types of Screening iii. Criteria for determination of the need for, and level of EIA iv. Purpose of Scoping v. Approaches to Scoping vi. Scoping Methods vii. EIA Terms of Reference	4

4.	**Baseline Environmental data collection: methodology** 1. Ambient Air Quality 2. Water including ground and surface 3. Soil Conservation 4. Noise and Vibrations 5. Hydrology, 6. Geology 7. Ecology and Bio-diversity 8. Socio-Economic environment 9. Traffic and other data	8
5.	**Impact Analysis/Assessment, Mitigation and Management** i. Impact Identification ii. Impact Analysis/Prediction: methodology iii. Characteristics of Environmental Impacts. Activity – Impact Characterization iv. Social Impact Assessment (SIA): introduction and methodology v. Evaluation of Impact Significance vi. Significance Criteria vii. Impact assessment for a. Land Use b. Air Pollution Monitoring, Prevention and Control c. Meteorology, Air Quality Modelling and Prediction d. Water Pollution Monitoring, Prevention and Control e. Ecology and Bio-diversity	12

	f. Noise and Vibrations g. Socio-Economic h. Hydrology, Groundwater and Water Conservation and Geology i. Soil Conservation j. Risk Assessment and Hazard Management k. Solid and Hazardous Waste Management	
6.	**Detailed Procedure to conduct public hearing** a. The Process b. Notice of Public Hearing c. Supervision and presiding over the hearing d. Proceedings e. Time period for completion of public hearing f. Arguments for and against public involvement	2
7.	**Final Appraisal of project** a. Grant or Rejection of Prior Environmental Clearance b. Validity of Environmental Clearance c. Post Environmental Clearance Monitoring d. Transferability of Environmental Clearance	1
8.	**Documentation of EIA** a. EIA report / report writing - Typical Elements of an EIA Report (as per prevailing EIA notification) b. Case studies: for EIA report a) iron ore or bauxite mines, b) coal based thermal power plants, c) sponge iron industry, d) cement, e) infrastructure such as airport/port (sea port),	12

	road/highways, construction of dam, f) sugar, g) distillery and h) housing/township projects c. Impact assessment statement d. Environmental management Plan e. Post Project monitoring-	
9.	**Environmental Audit** Definition of environmental audit and its importance for industries. Environment Compliance Audit. Basic structure of audit. Elements of an audit process and its importance with respect to Form-V. Environment Audit in India – Development of environmental auditing in India, Concept of ISO 14000, requirements of Rule 14 for environmental audit under Environmental Protection Act, 1986. Definitions –signatory, consumption audit, pollution audit, hazardous audit, solid waste audit, disposal audit, cost audit, investment audit, voluntary	11

Reference books

1. EIA notification published by Ministry of Environment, Forests and Climate Change, Government of India
2. Environmental Impact Assessment, Canter R.L., McGraw Hill International Edition.
3. Environmental Impact Assessment: Practical Guide for Professional Practices by Rathi AKA, Publisher: Gujarat Akar Unlimited, 2016
4. Preventive Environmental Management: An Indian Perspective by Dr. Shyam R. Asolekar & Dr. R. Gopichandran
5. Cleaner Production Strategies: Developing preventive Environmental Management by Tim Jackson published by Lewis publishers.
6. Practical guide to Environmental Management by Frank B Friedman

Course Code: ENV-602-MJ-TH

Course Name: Remote Sensing & GIS

Credit: 4

Course Outcomes:

CO602.1	Describe components of Remote Sensing, aerial photography and Geographical Information Systems
CO602.2	Summarise the working of remote sensing system and GIS system
CO602.3	Demonstrate use of remote sensing data and Choose GIS database for environmental study
CO602.4	Investigate available data and inspects trends of environmental components degradation
CO602.5	Evaluate the status of different environmental components based on remote sensing data analysis and GIS applications
CO602.6	Develop resource management plans, mitigation measures and restoration plan using RS and GIS technology

ENV-602-MJ-TH	**REMOTE SENSING & GIS (4 CREDITS)**	**Lectures 60**
Units 1	**Remote Sensing**	
1.	**History of remote sensing &Indian remote sensing**	2
2.	**Basics of remote sensing** • Definitions • Components • Active & Passive • EMR Spectrum • Radiation Laws	4
3.	**Types of remote sensing** Active and Passive, Optical, Infrared, Microwave, Hyperspectral, LIDAR	2
4.	**Resolution of RS data**	4

	• Spectral, Spatial, Radiometric, Temporal • Spectral Signatures • Spectral Reflectance Curve for Vegetation, Soil, Water	
5.	**Interaction of EMR** • Reflection, Absorption, Transmission, Scattering, Refraction, Emission, Reflectance • Atmospheric Windows	4
6.	**Basics of aerial photography** • Geometric features • Photo interpretation elements	2
7.	**Remote sensing platforms:** • Terrestrial Platforms, Airborne and Spaceborne	2
8.	**Remote sensing orbits:** • Types-geosynchronous, sun synchronous polar orbit	1
9.	**Scanning Systems**: • Multi Spectral Scanning, Push Broom, Whiskbroom, Overlap.	2
10.	**Types of sensors**- LISS III, LISS IV, AWIFS, PAN, CARTOSAT, LANDSAT, RADAR, SRTM, IKONOS	2
Unit 2	**GIS**	
1.	**History of GIS**	1
2.	**Components of GIS**	1
3.	**Types of data in GIS:** • Spatial, Non-Spatial Vector, Raster	4

	Vector-Point, Line, Polygon • Types of non-spatial data: Hierarchical, Network, Relational, Object oriented	
4.	**Shape of the earth:** Geoid, spheroid, ellipsoid concept	2
5.	**Map projections & datum** • Types of datum • Types of projections	4
6.	**Acquisition of spatial data** Scanning, Geo Referencing, Layer, Digitizing	3
7.	**Spatial analysis:** • Vector: overlay operations • Topology concept, Errors in topology Raster analysis	5
8.	**Satellite image processing and interpretation**: • Factors governing interpretability, • Elements of image interpretation. Image correction, rectification techniques.	4
9.	**GPS** • Concept and application • Indian navigation system IRNSS/NAVIC	1
10.	**Dem models** • DEM, DTM, DSM Applications of these models	1
Unit 3	**Applications**	

1.	**Applications of RS and GIS in environmental sciences** • Land use land cover • Natural hazards & disasters • Hydrology • Soil, water, air monitoring • Geological applications • Climate change • Agriculture • Wildlife, etc. • Case studies of analysis using RS GIS	8
2.	**Latest technological advancement and trends in RS GIS** • Wearable GIS • Tracking • Drone mapping and environmental survey, etc.	1

References

1. Lillisand, T. M. and Keifer, R. W. (1990): Remote Sensing and Image interpretation, John Willey and Sons, New York
2. Joseph G. (2003): Fundamentals of Remote Sensing, Universities Press, Hyderabad. • Haywood, Ian (2000): Geographical Information Systems, Longman
3. Chang, Kang-taung (2002): Introduction to Geographic Information Systems, Tata McGraw-Hill.
4. Burroughs, P. A (1986): Principles of Geographical Information Systems for land Resource Assessment, Oxford University Press.
5. Gupta, R. P. 2003. Remote sensing geology, Springer, New York

6. Barrett, E. C. and Curtis, L. F. 1999. Introduction to environmental remote sensing. Chapman and Hall

Course Code: ENV-603-MJ-TH

Course Name: Watershed Management

Credit: 2

Course Outcomes:

Course Outcome No.	Statements
CO.603.1	Describe watershed development.
CO.603.2	Discuss the significance of Watershed management.
CO.603.3	Compare different water harvesting methods
CO.603.4	Construct different watershed interventions.
CO.603.5	Design Soil and Water Conservation Measures
CO.603.6	Evaluate and Monitor Projects

ENV-603-MJ-TH	WATERSHED MANAGEMENT (2 CREDITS)	Lectures 30
1.	**Watershed Development** **Concept of watershed management** Definition, principle, objectives, Water shed morphology and characterization (with respect to size, elevation & slope, aspects & orientation, watershed shape, drainage network)	**5**
2.	**Watershed functions and surveys** Collection, storage, dispersal, habitat, Attenuation response, flushing, etc. Engineering surveys involved in watershed development: Topographical survey, drainage line survey, contour survey, common instruments used for survey. Hydrological survey: Methodology for groundwater investigation, investigation of surface springs, vertical distribution of ground water	**7**
3.	**Water balance studies and harvesting methods** Water balance and hydrologic equation, inflow to the watershed, outflow from the watershed. Water harvesting methods: traditional water harvesting structures such as *nadis, Khadin,*	**7**

	Rapats, Lakes, etc. contour bunding, graded bunds /field bunds, land levelling or terracing, farm ponds **Water harvesting in streams:** Biological measures, check dam, gully plug, Gabion structure, Overflow weir, earthen dam, Underground *bandhara*. Soil and water conservation aspects: contour trenches, continuous contour benches, live hedges, infiltration pit, *in situ* conservation through appropriate cultivation practices	
4.	**Watershed Interventions** Watershed Features: Surface Water Yield, Soil texture, Compactibility of soil, Infiltration Capacity of soil, Run off, Slope, etc. Watershed interventions in Ridge Area, Drainage Line and On- Farm Interventions. Designing and layout: contour trench, Earthen Contour bunds, gully plugs, Gabion Structures, underground dykes, earthen dams, farm bunds and dugout farm ponds.	**6**
5.	**Watershed management** Factors, problems associated with watershed management, project monitoring and result indicators, repair and maintenance, etc. Success stories of watershed management/water harvesting projects in India.	**5**

Reference:

1. Watershed manual by BK Kakde (BAIF and LEAD India publication)
2. Water Harvesting and Sustainable Supply in India by RN Athavale Centre for Environment Education ISBN: 8170337526
3. Watershed Hydrology by Peter Black; Lewis Publishers: ISBN 1575040271
4. Soil and water conservation engineering by R. Suresh – Standard Publishers and Distributors ISBN 8180140008

PRACTICALS RELATED TO COMPULSARY THEORY PAPERS

ENV-604-MJ-PR	PRACTICALS RELATED TO COMPULSARY THEORY PAPERS (4 CREDITS)
1.	**EIA & ENV AUDIT** 1. Industrial Process flowchart of given industry 2. EIA process Flowchart 3. Identification of Primary and Secondary Impact Assessment of given industry 4. Preparation of Impact Checklist of given industry 5. Preparation of Network Diagram for Impact Assessment of given industry 6. Preparation of Leopold Matrix Diagram for Impact Assessment of given industry 7. Structure of Form 1 and 1A for EC of given industry 8. Preparation of outline of EIA report of given industry 9. Preparation of Environmental Management Plan of given industry 10. Case study of any one project
2	**RS & GIS** 1. Aerial photo image interpretation 2. Aerial photo geometry, scale, measurement of relief numerical 3. Google Earth 4. GPS: collection of field data 5. Installation and familiarization with QGIS free software 6. Browsing and downloading data: From LANDSAT, BHUVAN 7. Topo sheet Geo referencing

	8. Topo sheet Digitization & Preparation of map and map layout 9. Satellite image registration 10. Satellite image enhancement and correction tools 11. Image classification: Supervised and unsupervised 12. Satellite image interpretation 13. Google Earth Engine
3.	**WATERSHED MANAGEMENT** 1. Mapping of watershed, marking of Ridge lines using Global Mapper and QGIS 2. Watershed Area Estimation using Global Mapper 3. Delineating Drainage Basin using topographic sheet 4. Watershed Drainage Estimation (Length, Width and Perimeter) using topographic sheet 5. Estimation Drainage Area using topographic sheet 6. Estimation of Relief Ratio of Drainage basin using topographic sheet 7. Estimation of Bifurcation ratio of Drainage basin using topographic sheet 8. Longitudinal Profile of River using topographic sheet 9. Watershed Slope Estimation using Global Mapper 10. Planning of Contour trench in watershed area 11. Planning of Contour bunds in watershed area 12. Planning of Gully plugs in watershed area 13. Watershed Planning exercises at milli-watershed level, location specific with identifying specific Watershed interventions required by conducting field visit.

Course Code: ENV-631-RP-PR

Course Name: Research Project-I

Credit: 4

Guidelines: It is expected that,

1. The student does project work equivalent to about fifteen (15) laboratory experiments throughout the third semester.
2. One bears in mind that the project work is a practical course and it is intended to develop a set of skills pertaining to the laboratory work apart from the cognition of students. Therefore, the guides should not permit projects that involve no contribution on part of student.
3. The project must have a clear and strong link with the principles of basic environmental science and/or their applications, environmental problem identification, problem solving and mitigation of environment problems.
4. The theme chosen should be such that it promotes better understanding of environmental science concepts and brings out the creativity in the students.
5. The evaluation of the project work must give due credit to the amount of the project work actually done by a student, skills shown by the student, understanding of the environmental science concepts involved and the final presentation at the time of viva voce.
6. The student can perform an Experimental/Theoretical/Computational Project in environmental science or interdisciplinary areas under the supervision of guide.
7. The student can learn the basics of the topic chosen for project, to learn how to do literature survey and set up the basic experimental/theoretical and computational techniques needed for the project.
8. The department encourage to students for projects both in experimental and theoretical areas of environmental science in collaboration with other institutes and industry.

The Project work shall consist of the following Criterions.

a. Project work is mandatory for all the M.Sc. students.
b. All the M.Sc. students will have to complete the Project work prescribed by the Board of Studies in environmental science Haribhai V. Desai College of Arts, Science and Commerce during the Semester III.
c. The Project work shall consist of the following Criterions.
    a) It is expected that students must finalize the Title of Project, Aim and objective, Significance, Literature survey, Materials required, Method and Application etc.
    b) Introduction to foundations of Project Work.

c) Introduction of Project Research Methodology.

d) Study of Data Collection Methods.

e) Project Problem Writing and Presentation Skills.

Note: At the time of project practical examination, the candidate must submit the certified project report by the project in-charge and HOD. A candidate will be allowed to appear for the Project practical examination only if the candidate submits a project completion report duly certified by the project in-charge and Head of the department.

Evaluation weightage:

Semester End Examination: 60 Marks

Internal Examination: 40 Marks

Course Code: ENV-610- MJ-TH

Course Name: Restoration ecology

Credit: 2

Course Outcomes:

CO612.1	Describe Eco Restoration
CO612.2	Discuss the significance of Restoration
CO612.3	Demonstrate steps involved in restoration of habitats
CO612.4	Illustrate procedure for ecosystem restoration of different habitats.
CO612.5	Evaluate a site for restoration by assessing the threats and selecting restoration methods
CO612.6	Devise plan for Eco-restoration.

ENV-610- MJ-TH	**RESTORATION ECOLOGY (2 CREDITS)**	**Lectures 30**
1	**Restoration Ecology** Eco Restoration: definition, principles, significances, guidelines, etc.	**4**
2	**Steps involved in Restoration** Identifying problem, assessment of project sites and parameters, identifying threats, methods available for restoration, selection of restoration methods, monitoring techniques for effective Restoration	6
3	**Applications of eco-restorations** Restoration of urban eco-system – e.g. ponds, lakes, river banks, avenue trees, biodiversity restoration through gardens, park, restoration of dumping grounds, restoration of eco system on hills, restoration of soil in urban areas, ground water resource – replenishment, sewage or wastewater – recycling for	8

	supporting ecosystems	
4	**Eco-restoration and industrial environment** Eco-restoration of mines (open cast), restoration of solid waste dumping sites, Improving aesthetics by partial restoration at industrial sites	6
5	**Restoration of other natural habitats/eco-systems** Mangroves, grasslands, wetlands, restoration of streams, degraded forest patches, coastal ecosystems, etc.	6

ENV-611-MJ-PR	**Practicals based on RESTORATION ECOLOGY (2 CREDIT)**
1	Rapid site assessment and data interpretation of any degraded ecosystem
2	Assessment of Restored Sites through Visit and Scientific Report writing based on visit (field visit)
3	Preparation of restoration plan for different habitats

References

1. Restoration of Nature by Prakash Gole
2. Restoration Ecology the new frontier – edited by Jelte Van Andel and James Aronson – Wiley-Blackwell publication ISBN 9781444336368
3. A source book for Ecological Restoration by Foundation for Ecological Security 2008
4. Foundations of Restoration Ecology (The Science and Practice of Ecological Restoration Series) - Donald A. Falk, Margaret Palmer, Joy Zedler, Richard J. Hobbs

Course Code: ENV -612-MJ-TH

Course Name: Forestry And Habitat Management

Credit: 2

Course Outcomes:

Course Outcome No	Statements
CO652.1	Acquire knowledge of Forest ecology and Ethnobotany
CO652.2	Understand principles of silviculture and its systems
CO652.3	Aware about Agroforestry, social forestry and Joint Forest management
CO652.4	Gain a knowledge of Forestry and Environmental Conservation
CO652.5	Apply their skills for forest resource management
CO652.6	Develop knowledge and integrated approach for forest management.

ENV - 612-MJ-TH	FORESTRY AND HABITAT MANAGEMENT (2 CREDITS)	Lectures 30
1.	**Forestry**: Definition of forestry and habitat management, Concepts, terms and terminologies, need, scope of the subject	2
2.	**Forest Ecology and Ethnobotany**: Forest as a ecosystem, Biotic and abiotic components, productivity, nutrient cycling, stresses, Forest types in India and conservation initiatives Role of Ethnobotany	3
3.	**Silviculture**: General Silvicultural Principles, ecological and physiological factors influencing vegetation, nursery system, Silvicultural systems – wood selection, felling, establishment and management of standards, technical methods and constraints, Silviculture practices in specialized ecosystems like Mangroves and Cold desert: Silviculture of trees - Traditional and advance methods, Silviculture of some of the economically important species in India	3
4.	**Agroforestry, Social Forestry, Joint Forest Management and Tribology**: scope and necessity; objectives, techniques,	2

	participatory approach, Research and Extension needs, stages of tribal economy, education, cultural tradition, customs, ethos and participation in forestry programs	
5.	**Forestry and Environmental Conservation**: Soil and water Conservation through Forestry, Environment; components and principles of conservation, impact of deforestation; forest fires and various human activities like mining, construction and developmental projects, population growth on environment, pollution.	3
6.	**Forest Management Systems**: Objective and principles; techniques; stand structure and dynamics, sustained yield relation; rotation of growing stock through management, Forest Working Plan, integrated approach, Forest Mensuration - Methods of measuring - diameter, girth, height and volume of trees; form-factor; volume estimation of stand, annual increment. Sampling methods and sample plots. Yield calculation; yield and stand tables. Forest cover monitoring through remote sensing, Geographic Information Systems, management and modelling. Surveying and Forest Engineering General principles, objects, types, methods	4
7.	**Forest Resources and Utilization:** Direct and indirect, environmentally sound forest harvesting practices, Non-Timber Forest Products (NTFPs) definition and scope - collection; processing and disposal.	3
8.	**Forest Protection:** Injuries to forest, Susceptibility of forests to damage, chemical and biological control, protection against fire and other natural disasters. Role of afforestation and forest regeneration, shifting cultivation and control.	2
9.	**Forest Economics and Legislation:** Fundamental principles of forest economics, Socio-economic analyses of forest productivity and attitudes, cost benefit analyses; estimation of demand and supply, national and international market and changes in production and consumption patterns; assessment and projection of market	8

	structures; role of private sector and co-operatives; role of corporate financing.; valuation of forest goods and service. Implications of forest laws and policies.	

Recommended Books

- Principal and Practices of Silviculture by LS Khanna
- Silviculture of Indian Trees (Revised Ed.) Vol 1-7 Editorial Board of Forest Research Institute, Dehradun (original 3 vol. by RS Troup)
- Forestry in India by AP Dwiwedi
- Forest and forestry by KP Sagaraya
- Handbook of Forestry by SS Negi
- Introduction to Forest Genetics by Wright
- Forestriars Companian by AR Malsekar
- Social Forestry by KM Tiwari
- Forest Ecology by AS Puri
- Revised Survey of Forest Types of India by Champian and Seth
- Forest Mensuration by LS Khanna
- Forest Utilization by Tribhuwan Mehta
- Manual of Joint Forest Management Training Manual
- Minor Forest Products of India by T Krishnamoorthy
- India's Forest Policies: analysis and Appraisal by LK Jha

ENV-613- MJ-PR	**Practical's based on FORESTRY AND HABITAT MANAGEMENT (2 CREDIT)**
1.	Silviculture techniques practicals
2.	Monitoring of ongoing silviculture plot
3.	Assessment of Urban forestry / industrial forestry

4.	Studies on the legislative cases under Forest act

SEMESTER IV

SEMESTER IV

Course Code: ENV-651-MJ-TH

Course Name: Solid & Hazardous Waste Management

Credit: 4

Course Outcomes:

Course Outcome No.	Statements
CO.651.1	Define solid and hazardous waste
CO.651.2	Explain the different sources, characteristics and composition of solid and hazardous waste
CO.651.3	Apply the concept of 3R's : Reduce, Reuse and Recycle in daily practices for waste management
CO.651.4	Differentiate various waste-to-energy technologies and their role in sustainable waste management
CO.651.5	Evaluate the environmental impacts of solid and hazardous waste management practices
CO.651.6	Develop knowledge and skills to design waste reduction and treatment technologies

ENV-651-MJ-TH	SOLID & HAZARDOUS WASTE MANAGEMENT (4 CREDITS)	Lectures 60
1.	**Introduction:** Definition, Historical development, Source and type-based classification, chemical and physical composition, Environmental and health impacts due to solid waste and its handling. Characterization: physical & chemical, implications for solid waste management. Factors affecting solid waste management: Climate, financial, cultural constraint, quality and quantity of waste.	6
2.	**Municipal Solid Waste management in India:** Generation, Collection, segregation, Transportation, Transfer stations, processing and disposal. Assessment of the existing situation & possible areas for improvement, EPR (Extended Producers Responsibility)	8

3.	**Industrial solid waste management:** Pulp and paper, Sugar, thermal power station, textile, food processing, mining, agriculture, etc.	8
4.	**Treatments and disposal:** Waste processing, Recovery of biological and chemical conversion products composting, biomethanation, RDF system, hydrolysis, Pyrolysis, plasma gasification, incineration, sanitary landfills. Resource conservation and recycling	8
5.	**Biomedical waste management:** Define, scope, categorization, segregation, packaging/colour coding and container used, treatment, transport and disposal, status in India. Biomedical Waste Management rules	6
6.	**Hazardous waste management:** Identification and sources, characteristics and categorization, Collection, segregation, packaging, labelling, transportation, processing (3R), risk assessment and waste management treatment and disposal, storage and leak detection, Site selection criteria, manifest system and records, Indian scenario, Responsibilities of authorities, hazardous waste management rules-2016	10
7.	**Radioactive waste management**	4
8.	**Electronic waste management:** A growing problem, sources, segregation, collection, recovery of valuable materials, treatment and disposal methods, E-waste (Management) Rules	4
9.	**Plastic waste management-** types of plastic, sources, the problem of plastic waste, degradation of plastics, recycling & alternatives to plastic, Maharashtra Plastic Ban notification 2018, Plastic waste management rules, 2016	4
10.	**Construction and demolition waste management**	2

Recommended Reference Material:

1. M.S. Bhatt and A sherefIlliyan. 2012. Solid Waste Management: An Indian Perspective.
2. S. Bhatia. 2007. Solid and Hazardous Waste Management. Atlantic publication.

3. Goel, Sudha (Ed.). 2017. Advances in Solid and Hazardous Waste Management
4. M.N. Rao & Razia Sultana. Solid and Hazardous Waste Management
5. M.N. Rao, Razia Sultana, Sri Harsha Kota, Anil Shah, Naresh Davergave. 2016. Solid and Hazardous Waste Management: Science and Engineering. 1st Edition. Butterworth-Heinemann publication.
6. George Tchobanoglous & George Tchobanoglous. 2002. Handbook of Solid Waste Management. 2nd edition. McGraw- Hill publication.

Course Code: ENV-652-MJ-TH

Course Name: Renewable & Non- Renewable Energy

Credit: 4

Course Outcomes:

Course Outcome No	Statements
CO652.1	List examples of renewable and non-renewable energy sources
CO652.2	Explain the principles behind renewable and non-renewable energy generation
CO652.3	Discuss the different power plants and its working for energy production
CO652.4	Compare and contrast the environmental and socio-economic impacts of renewable and non-renewable energy sources.
CO652.5	Discriminate Waste to Energy Conversion Systems
CO652.6	Write the current status of energy generation in India, its problems and develop innovative solutions to it

ENV-652- MJ-TH	RENEWABLE & NON- RENEWABLE ENERGY (4 CREDITS)	Lectures 30
1.	**Energy and Environment:** Energy indicator for development: human development index, UN definitions. Comparison of energy consumption by different nations. Human energy requirement, Energy use pattern in different parts of the world and its impact on the environment; Energy use pattern in India. Sources of energy and their classification; Energy forms and transformation. Impact of Energy Systems on environment. Renewable Energy Integration and Decentralized Generation Systems. Energy in Buildings, Energy Planning and Economics and Energy	8
2.	**Fossil Fuels:** Classification, composition, physiochemical characteristics; Energy content of coal, petroleum and natural gas; Formation, reserves, exploration/ mining and uses of Coal, Oil and Natural gas; Environmental problems	9

	associated with exploration / mining, processing, transportation & use. Case study of Thermal power plants	
3.	**Bio-energy:** Biomass composition and types; Conversion processes – pyrolysis, charcoal production, compression, gasification and liquefaction; Energy plantation; Biogas– production and uses, anaerobic digestion; Environmental constrains; Energy from solid Wastes – Sources, types, energy production. Bio- energy and Waste to Energy Conversion Systems, Energy Conservation and Management and Energy Laboratory.	8
4.	**Nuclear energy:** Fission and fusion, nuclear fuels, – Mining and processing of Uranium –concentration, refining, enrichment, fuel fabrication and fuel cycle; Nuclear reactors and radioactive waste; Environmental implications.	6
5.	**Solar Energy:** Sun as source of energy: Source of sun's energy, solar spectrum, solar radiation – absorption, reflection, scattering and diffusion in the atmosphere, Harnessing of solar energy, Photovoltaics, Solar collectors and concentrators, Solar thermal energy, Solar electricity generation, Solar heaters, dryers, and cookers; Energy Storage Systems and Fuel Cells, solar site assessment case study on site evaluation of site suitability, site approach, power generation.	8
6.	**Wind energy:** Wind power, Harnessing of wind energy, Power generation – wind mills, concentrators, wind characteristics and siting, environmental considerations; Wind energy potential in India. Numerical Methods and Computational Techniques, Wind Energy Conversion. Impact of wind energy systems on environment. Case study of wind energy generation: potential and challenges of utilizing wind energy.	6

7.	**Hydroelectricity:** Principles of generation of hydroelectric power, hazard related to hydropower generation and distribution, environmental impact Case study: Site assessment measurement of hydropower capacity of a site	8
8.	**Geothermal and Hydrothermal energy:** Sources – crust, high temperature aquifers, low temperature aquifers, reserves; Harnessing of geothermal energy – problems and prospects, Geothermal energy prospect in India. Hydrothermal energy; Tidal and wave energy, Problems and prospects. Small- Hydro and Other Renewable Energy Systems. Case study: suitability and potential of a location for geothermal power generation	7

Recommended Books

1. Renewable Energy – Environment and Development: M. Dayal; Konark Pub. Pvt. Ltd.
2. Alternative Energy: S. Vandana; APH Publishing Corporation
3. Solar Energy: Fundamentals and Applications, by Garg & Prakash, Tata McGraw-Hill Education, 2000
4. Nuclear Energy – Principles, practice and prospects: S. K. Agarwal; APH Publishing Corporation
5. Bio-Energy Resources: Chaturvedi; Concept Pub.
6. National Energy – policy, crisis and growth: V S. Mahajan; Ashish Publishing House Geography and Energy – Commercial energy systems and national policies: J.D. Chapman

ENV-653-MJ-PR	PRACTICAL'S BASED ON COMPULSORY THEORY PAPERS (4 CREDITS)
1.	**SOLID AND HAZARDOUS WASTE MANAGEMENT** 1. Estimation of organic carbon and organic matter in given waste sample 2. Estimation of moisture in solid waste 3. Estimation of potassium in solid waste 4. Estimation of phosphate in solid waste 5. Estimation of Calorific Value of given Fuel sample 6. Study Segregation process of Municipal Solid waste 7. Study types of Hazardous waste 8. Study color coding of Biomedical waste 9. Visit to Hazardous waste treatment plant / Landfilling sites
2	**Practicals based on RENEWABLE & NON- RENEWABLE ENERGY**
	1. Estimation of out heat of combustion of given fuel sample 2. Estimation of monthly average of daily solar radiations incident on earth surface of campus (Sunshine Recorder) 3. Analysis of wind power available for installation of wind mill 4. Estimation of calorific value of given wood sample 5. Study of carbonization processes (Charcoal making) by technique of wood pyrolysis

Course Code: ENV-681-RP-PR

Course Name: Research Project-II

Credit: 6

Guidelines: It is expected that,

1. The student does work equivalent to about 18-laboratory experiments throughout the fourth semester.
2. One bears in mind that the project work is a practical course and it is intended to develop a set of skills pertaining to the laboratory work apart from the cognition of students. Therefore, the guides should not permit projects that involve no contribution on part of student.
3. The project must have a clear and strong link with the principles of basic environmental science and/or their applications.
4. The theme chosen should be such that it promotes better understanding of environmental science concepts and brings out the creativity in the students.
5. The evaluation of the project work must give due credit to the amount of the project work actually done by a student, skills shown by the student, understanding of the environmental science concepts involved and the presentation of the final report at the time of viva voce.
6. The viva voce should be conducted at the time of evaluation of project work at least for twenty minutes per student.
7. Any ready-made material used in the report (such as downloaded pages from the web) must be clearly referred to and acknowledged.
8. Any non-adherence to this norm should attract a penalty by way of deduction in the marks awarded to a student.

The Project work shall consist of the following Criterions.

1) Working model (Experimental or Concept based simulation/Demonstration Related to environmental science).
2) Understanding of the project.
3) Experimental Details.
4) Data collection and Data Analysis.
5) Innovation.
6) Outcomes/Result.
7) Conclusion.

Note: *At the time of project practical examination, the candidate must submit the certified project report by the project in-charge and HOD. A candidate will be allowed to appear for the Project practical examination only if the candidate submits a project completion report duly certified by the project in-charge and Head of the department*

Evaluation weightage:

- Semester End Examination: 90 Marks
- Internal Examination: 60 Marks

Course Code: ENV-660-MJ-TH

Course Name: Environmental Toxicology Health & Safety

Credit: 2

Course Outcomes:

Course Outcome No	Statements
CO660.1	Acquire knowledge of fundamentals of occupational health and safety.
CO660.2	Understand the role and responsibilities of an occupational health and safety practitioner.
CO660.3	Aware about policies and legislation on safety in industries and workplace environments
CO660.4	Gain a knowledge of the principles of toxicology.
CO660.5	Apply their skills of epidemiological studies for Research and social awareness.
CO660.6	Develop knowledge of safety risk assessment

ENV-660-MJ-TH	ENVIRONMENTAL TOXICOLOGY HEALTH & SAFETY (2 CREDITS)	Lectures 30
1.	**Safety and Health Hazards** • Meaning and importance of safety, identification of potential safety and health hazards in industrial and development projects. • Reduction strategies, policies and legislation, international and national perspective. • Safety standards and management systems, OSHAS 18001, ISO 45001:2018 • Industrial health safeguards and implementation mechanisms.	7

	• Environmental & Safety policy and its implementation Safety as a tool for maximizing production and sustainable development.	
2.	**Health and Safety Risk Management** • Risk identification, allocation and mitigation strategies, • responsibilities and authority. • Potential of health risks in industrial and development processes, local and national policies. • Public awareness and participation in prevention procedures. • Industrial environmental conditions, emissions and noise abatement. • Risk reduction strategies for Hazards. • Ecological risk assessment	8
3.	**Toxicology** • Fundamental of toxicology, Basic concepts, toxicity and its impacts. • Nature of toxic effects, Acute and Chronic. • Industrial toxicants and hazardous materials. **Measurement of toxicity** • Measurement of toxicity- LD50, LC50, Nature of dosage- response relationship. • Use of dosage-response information, Factors influencing toxicity.	12

	• Lethality studies, physiological and metabolic effects on flora and fauna. **Evaluation of toxicity** • Physiological and metabolic effects of toxicants on human being; such as VOC and organic solvents, used in industry, heavy metals such as Hg, As, Cr, Cu, Pb, Al, Zn etc. Effects of Mutagenic, carcinogenic compound and Anti-cancer drugs on human health.	
4.	**Water and Airborne Diseases** • Human immune-system and its vulnerability to bacteria and viruses, preventive and curative measures, epidemics and their containment. • Potential and widespread effects of water and airborne bacteria and viruses. • Biological warfare and protective measures. • Safeguarding water sources and ambient air quality affected by biological disaster and its management. Role of WHO, NGOs & government	3

Reference Books

1. Principles of Environmental Toxicology,I.C.Shaw and J. Chadwick; Taylor& Francis Ltd.
2. Basic Environmental Health (2001): AnnaleeYassi, TordKjellstom, Theo de Kok, Tee Guidotti. Oxford University Press.
3. Environmental Health (2005): Dade W. Moeller, Harvard University Press. USA
4. Handbook of Environmental Health and Safety: Principle and practices. Herman Koren and Michael S. Bisesi. Lewis Publishers.
5. Essentials of Environmental Health (2006): Robert Friis. Jones & Bartlett Publishers Walker, C.H., Hopkin, S.P., Sibly, R.M., and Peakall, D.B. (2001):

6. Principles of Ecotoxicology. 2ndEd. Taylor & Francis, London.
7. Environmental Biology and Toxicology (2014): P. D. Sharma, Rastogi Publications.
8. Environmental Pollution and Toxicology: M.K. Rao. Manglam Publishers & Distributors.
9. Environmental Pollution: Health and Toxicology : S.V.S. Rana. Narosa Publishing House.
10. Toxicology (1999): A.Sood, Sarup and sons New Delhi.
11. Environmental Epidemiology : Anisa Basheer, Rawat Publication Jaipur, New Delhi
12. Links: https://www.epa.gov/risk https://www.epa.gov/risk/conducting-human-health-risk-assessment#tab
13. Industrial Hygiene & Chemical Safety: M.H.Fulekar, I. K.International Publishing House,
14. Principles of Fire Safety Engineering: Understanding Fire and Fire Protection (2014): Akhil Kumar Das. Prentice Hall India Learning Private Limited.
15. Industrial Safety and Environment (2013): AnupamaPrashar. S.K. Kataria& Sons.
16. Occupational Safety Management and Engineering (2001): Willie Hammer, Prentice Hall.
17. Fundamentals of Occupational Safety and Health, Mark A. Friend, James P. Kohn
18. Industrial Safety, Health Environment and Security, Basudev Panda.Laxmi Publications
19. Occupational Hygiene(1995):Blackwell Science,Harrington, J.M. & K. Gardiner. Oxford.
20. Industrial Safety, Health and Environment Management Systems: R..Jain and S. Rao.

Course Code: ENV-661--MJ-TH

Course Name: Environmental Policy & Climate Change

Credit: 2

Course Outcomes:

CO661.1	Outline the climate dynamics
CO661.2	Recognise the Intricacies of climate change and policies
CO661.3	Demonstrate the significance for sustainability in protecting the environment
CO661.4	Categorise the sector wise mitigation measures for climate change
CO661.5	Summarize the role of climate in economics
CO661.6	Create a pathway for sustainable development

ENV-661--MJ-TH	**ENVIRONMENTAL POLICY & CLIMATE CHANGE**	**Lectures 30**
Unit 1	**UNDERSTANDING CLIMATE DYNAMICS** • **Earth's Paleoclimatic history:** Earth-Life Evolution, Mass Extinctions, Ongoing 6th Extinction • **Climate Forcings:** Volcanism, Plate Tectonics, Solar Cycles, Magnetic Storms, Glaciation and Inter-glaciation, Global Conveyor belt, Climatic teleconnections, Urbanisation & Industrialization • **Proxies of climate change:** Tree rings, microfossils, oxygen-carbon	10
Unit 2	**Climate Change impacts and Protection policies** • **Sectorial impacts of climate change:** Impacts of CC on Health, Agriculture, Water Resources, Biodiversity, Coastal Areas • **Regional Vs. Global changes**	10

	• **Sector-wise Adaptation & Mitigation Measures** • **History of Global Action Plans:** Stockholm Declaration 1972, Nairobi Declaration 1982, 1st Earth Summit Rio 1992, Kyoto Protocol 1997, Copenhagen Summit 2008, Durban Summit 2011, Paris Agreement 2015 • **Intergovernmental Panels working towards mitigating Climate Change:** IPCC, UNFCCC	
Unit 3	**Climate Economics:** • Carbon Sequestration; Role of agricultural land in carbon sequestration; Concept of Carbon footprint, carbon credits and carbon trading • Concept of water footprint, water trading and its relationship to climate change • India's take on Climate Change; Stakes of Developing and Developed Nations • Mitigation measures at different scales – global, National, organizational, Individual • Green Credit • Biodiversity credits	10

References:

1. The Atmosphere – Lutgens & Tarbuck
2. IPCC Reports on Climate Change
3. Fundamentals of Environmental Science: A Global Concern – Cunningham & Cunningham
4. Environmental Science – Daniel Chiras (Case Studies)
5. The Climate Fix: What Scientists and Politicians Won't Tell You About Global Warming by Roger Pielke, Basic Books (2010)

6. The Climate Solution: India's Climate Change Crisis and What We Can Do About It by Mridula Ramesh, Hachette India (2018).
7. This Changes Everything: Capitalism vs. the Climate by Naomi Klein, Penguin (2015).
8. What Is Climate Change? (What Was?) by Gail Herman (Author), Illustrated by John Hinderliter, Penguin Workshop (2018).
9. Climate Change Biodiversity and Green Economy by H.S. Sharma S. Padmaja and Ganesh Sharma, Concept Publishing Company Pvt. Ltd. (2013).
10. Climate Change by Joseph Romm, OUP US (2018).
11. Environment and Sustainable Development by M.H. Fulekar, Bhawana Pathak, R K Kale, Springer Nature (2013).
12. Sustainable Development in Digital Era by Dr. Aparna Mishra, Dr. Vikas Dahiya, Dr. Kamini Tandon, JSR Publishing House LLP; (2019).
13. The Age of Sustainable Development by Jeffrey D. Sachs and Ban Ki–moon, Columbia University Press (2015).
14. Target 3 Billion: Innovative Solutions Towards Sustainable Development by APJ Abdul Kalam, Srijan Pal Singh, Penguin India (2011).

Course Code: ENV-662-MJ-TH

Course Name: Environmental Biotech & Nanotech

Credit: 2

Course Outcomes:

Course Outcome No	Statements
CO662.1	Acquire knowledge of fundamentals of Environmental Biotechnology.
CO662.2	Understand the basic tools and techniques in biotechnology
CO662.3	Aware about Environmental applications of Biotechnology
CO662.4	Gain a knowledge of Nanotechnology
CO662.5	Apply their skills of Biotechnology studies for nanoparticles
CO662.6	Develop knowledge of environmental nano remediation.

ENV-662-MJ-TH	ENVIRONMENTAL BIOTECH & NANOTECH (2 CREDITS)	Lectures 30
Unit 1	**Environmental Biotechnology: Concepts and Scope:** The scope of environmental biotechnology; Concept and various applications. Biosafety, Recombinant DNA guidelines	2
Unit 2	**Basic Biotechnological Tools and Techniques:** • Background, scope, various biotechnology tools – nuclear acids, molecular cloning, cloning vectors, transformation, selection of transformation, Polymerase chain reaction (PCR), DNA fingerprinting • DNA Sequencing techniques: Maxam-Gilbert's method, Sanger's Dideoxy method, Next generation sequencing, Environmental metagenomics: concept, pipelines and applications	8
Unit 3	**Environmental Applications of Biotechnology:**	5

	• Biosensors, Bio-monitors for detecting environmental pollutants • **Bioremediation:** Concept; Natural and Engineered; in situ, ex situ, bio stimulation, bioaugmentation, monitored natural attenuation, role of bioremediation in controlling various pollution problems; • **Phytoremediation:** Abatement of different types of pollution using plants, mechanistic insights and case studies • **Xenobiotic degradation**, Biomining and Bioleaching • **Biofuels:** Alternative source of fuel production; mechanism of various biofuel productions. Fermentation technology using bioreactors, Bio methanation.	
Unit 4	**Environmental Nanotechnology:** • **Overview** - Definition, Historical perspectives, Scope, Environmental applications	2
Unit 5	**Types, Structures of Nanomaterials:** Different types of nanomaterials: Silver, Gold, Zinc, Iron, Silica, Titanium, Carbon-based nanomaterials, metal oxide nanomaterials; Nano-membranes, Nano-wires, Nano-needles, Nano-cones, Nano- rods, Nano-combs, Nano-walls	3
Unit 6	**Synthesis and Characterization of Nanoparticles:** Basics of nanoparticle synthesis techniques (Chemical, Physical and Biological synthesis); Functionalization of nanoparticles Techniques for characterization: UV-Visible Spectrophotometry, Scanned electron microscope (SEM), Transmission electron microscope (TEM), Scanning tunneling microscope (STM), Atomic force microscopy (AFM), X-ray diffraction (XRD)	5
Unit 7	**Environmental Nano remediation**:	5

	• Definition, current applications of nanotechnology for environmental cleanup such as use of non-zerovalent iron (nZVI), bimetallic nanoparticles, titanium dioxide Nano membranes, carbon nanotubes for wastewater, groundwater and soil remediation; • **Implications of Environmental Nanotechnology**: Risks associated with nanomaterial applications to human health and ecology; Environmental protection laws, rules and regulations to prevent hazardous impact of nanotechnology; Solutions and alternatives.	

ENV-663- MJ-PR	**Practicals based on ENVIRONMENTAL BIOTECH & NANOTECH (2 CREDITS)**
1.	1. Genomic DNA extraction of Bacteria/ plants/ water/soil/contaminated samples 2. PCR analysis of extracted genomic DNA samples and electrophoretic analysis of PCR products 3. Sequence analysis using BLAST platform 4. Synthesis of nanoparticles Physical, Chemical and Biological methods 5. Characterization of synthesized nanoparticles