



Solapur University, Solapur

Choice Based Credit System (CBCS)

Syllabus

M.Sc. Part I & II Environmental Science

To be implemented from the year 2016 onwards

School of Earth Sciences

Solapur University, Solapur

M.Sc Environmental Science

School of Earth Sciences
Solapur University
M.Sc Environmental Science (CBCS Syllabus) - 2016

Semester	CODE	TITLE OF THE PAPER	Semester Exam			L	T	P	Credit
			Theory	IA	Total				
First		Hard Core							
EST	HCT1.1	Fundamentals of Environment	70	30	100	4		4	
	HCT1.2	Environmental chemistry	70	30	100	4		4	
	HCT1.3	Computer Applications	70	30	100	4		4	
		Soft Core (any One)							
	SCT1.1	Introduction to Geo-science	70	30	100	4		4	
	SCT1.2	Geomorphology	70	30	100	4			
		Practical (Hard Core)							
	HCP1.1	Practical HCP1.1	35	15	50		2	6	
	HCP1.2	Practical HCP1.2	35	15	50		2		
	HCP1.3	Practical HCP1.3	35	15	50		2		
		Soft Core (Any One)							
	SCPI.1	Practical SCPI.1	35	15	50		2	2	
	SCPI.2	Practical SCPI.2	35	15	50		2		
		Soft skill ICT, Scientific English, Tutorial			25		01	1	
		Total for First Semester	420	180	625			25	
Second		Hard Core							
EST	HCT2.1	Biodiversity and Conservation	70	30	100	4		4	
	HCT2.2	Water and wastewater Engineering	70	30	100	4		4	
		Soft Core (any One)							
	SCT2.1	Remote sensing and GIS in Environmental science	70	30	100	4		4	
	SCT2.2	Hydrogeology	70	30	100	4			
		Open Elective (Any One)							
	OET2.1	Analytical techniques and instrumentation	70	30	100	4		4	
	OET2.2	Oceanography and marine biology	70	30	100	4			
		Practical (Hard Core)							
	HCP2.1	Practical HCP2.1	35	15	50		2	4	
	HCP2.2	Practical HCP2.2	35	15	50		2		

		Practical (Soft Core) (any one)						
	SCP2.1	Practical SCP2.1	35	15	50		2	2
	SCP2.2	Practical SCP2.2	35	15	50		2	
		Practical Open Elective(any one)						
	OEP2.1	Practical OEP2.1	35	15	50		2	2
	OEP2.2	Practical OEP2.2	35	15	50		2	
		Soft skill ICT, Scientific English Tour and Tour report , Tutorial			25		01	1
		Total for Second Semester	420	180	625			25

*Fieldwork of 10-15 days is compulsory. The field work may be stretch or divided into parts in the academic year

Third		Hard Core	Theory	IA	Total			
EST	HCT3.1	Environmental pollution	70	30	100	4		4
	HCT3.2	Environmental biotechnology	70	30	100	4		4
		Soft Core (any One)						
	SCT3.1	Environmental statistics	70	30	100	4		4
	SCT3.2	Digital image processing	70	30	100	4		
		Open Elective (Any One)						
	OET3.1	Research methodology	70	30	100	4		4
	OET3.2	Meteorology	70	30	100	4		
		Practical (Hard Core)						
	HCP3.1	Practical HCP3.1	35	15	50		2	4
	HCP3.2	Practical HCP3.2	35	15	50		2	
		Practical (Soft Core) (any one)						
	SCP3.1	Practical SCP3.1	35	15	50		2	2
	SCP3.2	Practical SCP3.2	35	15	50		2	
		Practical Open Elective(any one)						
	OEP3.1	Practical OEP3.1	35	15	50		2	2
	OEP3.2	Practical OEP3.2	35	15	50		2	
		Soft skill ICT, Scientific English, Tutorial			25		01	1
		Total for Third Semester	420	180	625			25

Fourth		Hard Core	Theory	IA	Total			
EST	HCT4.1	Environmental policy, acts, Laws and environmental Management system	70	30	100	4		4
	HCT4.2	Environmental toxicology	70	30	100	4		4

		and Safety						
	HCT4.3	Environmental Impact Assessment and Environmental Audit	70	30	100	4		4
		Soft Core (any One)						
	SCT4.1	Dissertation	70	30	100	4		4
	SCT4.2	Environmental geology and Disaster Management	70	30	100	4		
		Practical (Hard Core)						
	HCP4.1	Practical HCP4.1	35	15	50		2	6
	HCP4.2	Practical HCP4.2	35	15	50		2	
	HCP4.3	Practical HCP4.3	35	15	50		2	
		Soft Core (Any One)						
	SCP4.1	Practical SCP4.1	35	15	50		2	2
	SCP4.2	Practical SCP4.2	35	15	50		2	
		Soft skill ICT, Scientific English Tour and Tour report , Tutorial			25		01	1
		Total for Fourth Semester	420	180	625			25

*Fieldwork of 10-15 days is compulsory. The fieldwork may be stretch or divided into parts in the academic year,

TOTAL DURATION OF THE COURSE: 2 YEARS

N.B.: Each semester will have 1 credit (25 marks) for- field training for long tour/ in plant training/remote sensing institute visit or field work, data acquisition related to dissertation.

M.Sc. Environmental Science, Part I, Semester – I (CBCS Syllabus) - 2016

EST- 101: Fundamentals of Environment

Marks: External 70

Internal 30

Unit	Topic	Credit	Lectures
UNIT-1	Introduction to Environment Definition, principle and scope of environmental science, man & environment, media and people, decision making and applications in environmental science, environmental ethics, concept of Gaia hypothesis.	1	14
UNIT-2	Components of Environment Environmental factors: Atmosphere, Hydrosphere, Lithosphere and biosphere and their interrelationships. Atmosphere: structure and composition atmosphere. Lithosphere: structure and composition of lithosphere, soil: characteristics, soil profile, soil erosion. Hydrosphere: Global water balance, Hydrological cycle, Biosphere: Concept of biosphere, physical, chemical and biological factors of environment.	1	14
UNIT- 3	Ecosystem dynamics Concept of ecosystem, abiotic and biotic components, Tolerances, ecological amplitude, limiting and inhibiting effects. Climatic (light and temperature) factors, edaphic factors, Biotic factor, Energy flow in ecological system, concept of productivity, food chain, food web, ecological pyramids, concept of Habitat, ecological niche, guild, concept of ecotone, edge effect, ecological succession, mechanism of succession, concept of climax.	1	14
UNIT-4	Population dynamics and community ecology Concepts of population ecology, population dynamics, characteristics of population: natality, mortality, fecundity, biotic potential, growth rate, density, age distribution, prey predator relationship, population explosion; Adaptations, Concept of community, interspecific and interspecific competition, concept of carrying capacity, population change-k and r selections.	1	14

List of Practical ESP-105 based on EST- 101: Fundamentals of Environment

Marks: External 35

Internal 15

1. Identification of common weeds, Herbarium preparation,
2. Biodiversity categorization and measurement studies.
3. A visit to aquatic ecosystem and methods for water and plankton collection,
4. Plankton identification and quantification from river / lake water samples,
5. Vegetation studies by line, Quadrates and belt transect methods and their analysis.
6. Qualitative and quantitative estimation of Phytoplankton.
7. Estimation of Primary Productivity by light and dark bottle method.
8. Estimation of primary productivity of grasses by Harvest method.

References:

- Anjaneyulu. Y, (2004), Introduction to Environmental Science. B. S. Publications.
- D. Daniel Chiras, (2001), Environmental Science, 6 th Ed., Jones and Bartlett Publishers.
- Daniel Botkin and Edward Keller (1997), Environmental Sciences, John Wiley and Sons, New York.
- Edward J. Kormondy (2009), Concepts of Ecology (Fourth Edition)- Prentice Hall of India Pvt. Ltd. New Delhi.
- Eldon D. Enger and Bradley F. Smith (1995), Environmental Science, WCB Publishers, Boston.
- Gaudy, A.F. and Guady, E.T. (1980), Microbiological Methods for Environmental Scientists and Engineers McGraw Hill.
- Grainer, J.M. and Lynch, J.M. (1984). Microbial Methods for Environmental Biotechnology: Academic Press.
- Linton, A. H. and Burns, R.G. (1982) Microbes, Man and Animals: The Natural History of Microbial Interactions : John Wiley and Sons.
- P.D. Sharma, (1986), Environmental Biology Rastogi Publication, Meerut.
- P.D. Sharma, Ecology and Environment(1989), Rastogi Publication, Meerut.
- Pelczar, M.J. and Chan ECS, 1981, Elements of Microbiology, John Wiley and Sons, McGraw Hill.
- Wright. R.T, and Nebel. B. J, (2004), Environmental Science, 8th Ed. Prentice Hall India Ltd.

EST- 102: Environmental Chemistry**Marks: External 70****Internal 30**

Unit	Topic	Credit	Lectures
UNIT-1	Basic concepts of Environmental Chemistry Classification of elements, theory of valency, basic concepts of colorimetry from quantitative chemistry, molecular weight, equivalent weight, mole concept, normality, molarity, molality, molar solution, standardization, primary standards, secondary standards, titration, principle of colorimetry, Lambert's law, Beer's law, Nernst distribution law, principle of colloidal chemistry, emulsions, adsorption, absorption, Energy- Definition, types (kinetic and potential), forms of energy; laws of thermodynamics (First & Second), stoichiometry, Gibbs energy, chemical reactions, chemical potential, chemical equilibrium, acid-base reactions, chemical speciation	1	14
UNIT-2	Chemistry of air Structure and Composition of air, particles ions and radicals in the atmosphere; chemical processes for formation of inorganic and organic particulate matter. Chemical aspects of acid rain and photochemical smog, Formation of acid rain; adverse effects of acid rain; chemistry and concepts of green house effect, ozone layer depletion, CFCs, NO ₂ , HC and PAN, other toxic chemicals in environment, pesticides, insecticides, arsenic, cadmium, lead, mercury, carbon monoxide and ozone, MIC and other carcinogens.	1	14

UNIT- 3	Chemistry of water Chemistry of water; structure of water molecule, hydrological cycle, distribution of water, water quality parameters and standards, Physico-Chemical parameters of water, concept of DO, BOD, COD, sedimentation, coagulation, filtration, Redox potential, types of water, sampling techniques, sources and uses of water, solubility of compounds in water; dissociation constant, ionic product of water, the hydrogen ion exponent (pH), buffer solutions, alkalinity and acidity, the carbonic acid system, buffering in water system, metals in aqueous solution.	1	14
UNIT-4	Chemistry of Soil Introduction to Soil Chemistry, Formation of soil, weathering of rocks, composition, soil profile, reactions in soil, Cation and anion exchange phenomenon, Nature and composition of soil, soil water - soil air - soil temperature -mechanical composition-structure and texture, physical and Chemical properties of soil,. Soil survey, Soil Fertility, chemical and mineralogical composition of soils, soil organic matter, soil nutrients, concept and role of macronutrients and micronutrients, biogeochemical cycles (nitrogen, oxygen, carbon, sulphur, phosphorus etc), factors affecting the soil quality; adsorption of contaminant in soil.	1	14

List of Practical ESP-105 on EST- 102

Environmental Chemistry

Marks: External 35 Internal 15

1. Study of Sampling and storage techniques of water and soil
2. Determination of pH and Electrical conductivity (EC) calibration and metric titration
3. Determination of Dissolved Oxygen (DO) by Winkler's method.
4. Determination of Biochemical Oxygen Demand (BOD)
5. Determination of Chemical Oxygen Demand (COD)
6. Determination of Solids (TDS, TSS and TS)
7. Determination of Hardness (Ca, Mg and Total Hardness)
8. Determination of Alkalinity and Acidity

References:

1. A.K. De (2001), Environmental Chemistry, New Age International Publishers, New Delhi.
2. A.Singh and R. Singh (2005), Surface Chemistry, Campus Book International, New Delhi, India.
3. B.K. Sharma, (2001), Instrumental Methods of Chemical Analysis, Goal Publishing House, Meerut, India.
4. Dara S S.,(1998), A text book of environmental chemistry and pollution control, S. Chand & Company Ltd, New Delhi
5. Ewing G.W, (1985), Instrumental Methods of Chemical Analysis, 5th Edition McGraw Hill, U.K.
6. Howard S Peavy (2003), Environmental Engineering, Tata Mc Graw Hill Publishing Company Ltd., New Delhi.
7. J.D. J., Denney, R.C., Jeffery, G.H and Mendham, J. (1999), Vogel's Text Book of Quantitative Inorganic Analysis, Barnes, 6th Edition, Pearson Education Ltd., U.K.
8. P. W. Atkins and Julio de Paula (2006), Atkins' Physical Chemistry, Oxford University Press, NY, USA.
9. R. D. Madan (2010), Modern Inorganic Chemistry, S. Chand & Company Ltd, New Delhi, India.

10. Roy I Donalue, Raymond W Miller and John C Shiekluna (1987), An Introduction to Soils and Plant Growth, 5th Ed, Prentice Hall of India.

EST- 103: Computer Applications

Marks: External 70

Internal 30

Unit	Topic	Credit	Lectures
UNIT-1	History of computer, Basics of computers- An introduction to computers, development of computers, Hardware and Software. Fundamentals of computers – Operating systems, Input to the computers, Storage devices, central processing unit, Computer output, Compact Disk Cartridges, Floppies, pen drives, etc.	1	14
UNIT-2	Personal Computers- Data communication and networks – Application software, word processing, spread sheets, Data management and graphics. Data Base Management System, Multimedia. General Idea about the networking, LAN, WAN, databases, etc.	1	14
UNIT- 3	Use of information technology in environmental studies, Definition, scope of information technology, history and present status of information technology, application of IT in environmental protection. Environmental sciences and the Internet. Use of standard software's for representing various data in graphs, diagrams, charts etc. Website Design.	1	14
UNIT-4	Computer applications, technology for environmental sciences. Introduction to Bio informatics – scope, tools and applications. Application of Computer in Earth Sciences - Geoinformatics, Geology, Geography, hydrology, Environment or in thematic map preparation and modeling	1	14

List of Practical ESP-106 on EST- 103: Computer Applications.

Marks: External 35 Internal 15

1. Tabulation of data.
2. Introduction to computer system and its components.
3. Applications of computers in Earth Sciences
 - a) Report presentation using MS-Office
 - b) Simple statistical work using Excel spread sheet
 - c) Presentation using Power Point
4. Representation of Statistical data using computer in two and three dimensional forms by
5. Use of Data sheet and data management.
6. Creating table for given scientific table.

7. Plotting of scatter diagram using computer in Excel.
8. Email and internet accessibility in Environmental Sciences.

References:

1. Campbel, R.C., (1974), Statistics for Biologist, Cambridge University Press, UK.
2. Ford, E.D. 2000, Scientific methods for Ecological Research. Cambridge University Press, Cambridge.
3. Rosner, B. (1986), Fundamentals of Biostatistics, Duxbury Press, Boston.
4. Zar, J.H. (1984), Biostatistical Analysis. Prentice-hall, Inc Englewood Cliff, New Jersey.
5. INTERNET – CDC publication, India.
6. Snedecor, W and G. Cochran, (1967), Statistical Methods. Oxford and IBH Publishing Co. Calcutta.
7. Bodkin, Daniel D. (1995), Environmental Science- Earth As a Living Planet, John Wiley & Sons, New York.
8. Clark, C.W. (1976), Mathematical Bioeconomics: Optimal Management of Renewable Resources, John
9. Gore, Anil and Paranjpe, S.A. (2000), A Course on Mathematical and Statistical Ecology, Kluwer.

Subject Elective (any one)
EST-104(A): Introduction to Geo-science

Marks: External 70

Internal 30

Unit	Topic	Credit	Lectures
UNIT-1	Introduction to Environmental Geo-science Environmental Geo-science: Fundamental concepts, Primary differentiation and formation of core, mantle, crust, magma generation, eruptions and volcanoes. Formation and classification of rocks: plate tectonics – sea floor spreading, mountain formation, rock deformation and evolution of continents, weathering and soil formation.	1	14
UNIT-2	Environmental Geochemistry Concept of major, minor and trace elements. Mobility of elements, geochemical cycles, sedimentary cycle, deforestation and erosion, Geo-indicators, geological consequences of industrialization, groundwater pollution and management-case studies related to fluoride, pesticide, fertilizers and arsenic contaminations in India, Mineral resources in relation to plate tectonics and geology, geology of mineral resources, mineral sources and reserves, distribution of mineral resources in India. Environmental impact of exploitation, processing and smelting of minerals.	1	14
UNIT- 3	Atmosphere Radiation, conduction and convection, forms of condensation-dew, frost, fog, mist, smog and cloud, Atmospheric stability, adiabatic character, dry and wet adiabatic lapse rate, Turbulence and diffusion, Different layers and their characteristics, meteorological aspects-inversions, mixing height, wind-rose, electromagnetic radiations, solar radiation and terrestrial radiation, heat budget, Temperature measurements and controls, Environmental lapse rate, humidity, mixing ratio. Application of	1	14

	meteorology to air pollution study.		
UNIT-4	Environmental Geo-Climate Elements of Weather and Climate, classification, energy balance in atmosphere, greenhouse effect, Geo-strophic wind and gradient wind, cyclones, Forms of cloud condensation; Precipitation, Thunderstorms, floods and droughts, Acid rain, Effects of acid rain on environmental components, drinking water standard, introduction to weather forecasting models.	1	14

List of Practical (minimum eight) ESP-106 based on EST- 104(A)

Introduction to Geo-science

Marks: External 35 Internal 15

1. Preparation of global and Indian natural hazard maps
2. Interpretation of transport of pollutants in the subsurface
3. Preparation of local level maps of pollution case studies
4. Preparation of groundwater flow nets and assessment of probable contaminant movement in the subsurface
5. Problem solving on movement of pollutants in the subsurface using simple computer assisted models
6. Study of Geomorphological models: a) Coastal plain b) Volcanoes c) Fault blocks mountains d) Folded mountains e) Glaciers f) Canyon g) Cost line
7. Petrology: Identintification of major rock types 8. Mineralogy: Identification of common rock forming minerals
9. Study of the conventional signs and symbols from toposheet and their interpretation
10. Study of the conventional signs and symbols from weather map and interpretation of weather map.

Reference Books

1. A.N. Strahler and A.H. Strahler (1973), Environmental Geo-science-Hamilton Publication
2. Basu S.K. (2003), Handbook of Oceanography, Global Vision, Delhi.
3. Bell F. G., (1998), Environmental geology: Principles and practice. Blackwell Sc. Oxford.
4. Bennett, M. R. and Doyle, P. (1997), Environmental geology - Geology and the Human Environment. John Wiley and Sons.
5. Botkin, Daniel B. and Keller, Edward A (2007), Environmental Science: Earth as a Living Planet. 6th ed. John Wiley & Sons, USA.
6. Bouwer, H. (1978), Groundwater Hydrology. McGraw-Hill, New York.
7. Butz, S.D. (2004), Science of Earth Systems. 2nd ed. Thomson Delmar Learning, USA
8. Chamley, H. and Chamley, H. (2003), Geosciences, Environment and Man Elsevier Science & Technology pub.
9. Chiras,D.D (1989), Environmental Science-A frame work for decision maling- Addison-Wesley publishing company- New York.

Subject Elective EST-104(B): GEOMORPHOLOGY

Marks: External 70

Internal 30

Unit	Topic	Credit	Lectures
UNIT-1	Fundamental concept in Geomorphology Define, Nature, concept, Scope of Geomorphology. Mechanical, Chemical, Biological, Soil formation. Drainage System, Patterns.	1	14

UNIT-2	Erosion Cycle of erosion: Davis, Penck, L.C. King, Rejuvenation: & Polycyclic Relief Erosion & Depositional Land form Associated with River, Wind, Glacier, Karst, Marine.	1	14
UNIT-3	Climatic Geomorphology and Earth Movement Climate & land form, humid, sub-humid, arid & semi-arid nature of weathering Continental drift theory & concept plate tectonic theory, crustal movements.	1	14
UNIT-4	Application of Geomorphology Settlement, Construction (dam, road, building, tunnel etc.), Disaster management.	1	14

PRACTICAL ESP -106 based on EST-104(B)

GEOMORPHOLOGY

Marks: External 35

Internal 15

1	Study of Natural resources	Water, Forest, Minerals, Soil,
2	Study of human resources	Transportation, settlement, agriculture, industries, education facility, cultural places, population
3	Quantitative	Semi average method, leastsquare method, exponential growth rate of population, lorenze curve, rank size rule, nearest neighbor techniques, nelson methods of town classification, accessibility of transport network, crop combination method
4	Climatic Data	Interpretation of Indian daily weather report, Wind Rose diagram, Line Graph, Dispersion diagram

Reference Books:

- Fundamental of Geomorphology, R.J. Rice
- Geomorphology, R.J. Chorley, S.A.Schumm, D.E. Sugden
- Principle of geomorphology, W.D. Thornbury
- Geomorphology, Majid Husain
- Indian Geomorphology, H.S.Sharma.

PART- I

SEMESTER – II

EST – 201 Biodiversity and Conservation

Marks: External 70

Internal 30

Unit	Topic	Credit	Lectures
UNIT-1	Introduction to Biodiversity: Level of biological organization, the global perspective, Global Environmental changes, Biogeographical regions of India, Biodiversity concepts and patterns, Microbial diversity, Plant diversity, Agro-biodiversity, Soil biodiversity. Types: Species diversity, Genetic diversity, Pattern diversity, Alpha, Beta and Gama diversity, Gradients of Biodiversity, Ecosystem diversity, Measuring of species diversity, richness and evenness, factors related to tropical species diversity.	1	14
UNIT-2	Factors governing biodiversity: a. Biodiversity hot-spots, diversity distribution, factors affecting diversity, Mega diversity regions of India, Diversity trends of different ecosystem, Major forest types and distribution of wild life in India. b. Impact of exotic species, disturbance on diversity, dispersal, diversity-stability relationship, keystone species.	1	14
UNIT- 3	Conservation of Biodiversity: a. Threats to biodiversity, Human interference and habitat destruction, Human & Wildlife Conflicts, biological invasion. Importance of biodiversity conservation, direct and indirect benefits, Bioprospecting, Biopiracy, REDD. b. Strategies for biodiversity conservation. In-situ and ex-situ conservation, wildlife habitats and their conservation. Protected Area network, Biosphere Reserves, National Parks, sanctuaries, sacred groves; ex-situ conservation, gene pools, germplasm banks.	1	14
UNIT-4	Biodiversity Action Plan: International conventions on biodiversity, IUCN Criteria, endemic, extinct, endangered, vulnerable and rare species, Red Data Book. National Policy and Action Plan, Role of Forest Department in Conservation, Biodiversity Legislation in India. Integrated Protected Area System, RAMSAR sites. Existing conservation projects: Tiger, Rhino, Elephant, Turtles, Crocodiles, coral reefs and Mangroves.	1	14

INTERNAL EVALUATION 30 MARKS

(Seminar + term paper + test)

PRACTICAL (minimum eight) ESP -205 based on EST- 201

BIODIVERSITY AND CONSERVATION

Marks: External 35 Internal 15

1. Determination of phytoplankton diversity of a water body by Nygaard index.
2. Determination of population density of insects/birds/reptiles/mammals.
3. To observe the impact of invasive species on vegetation and species composition.
4. To study the impact of disturbance on vegetation.

5. Preparation of a list of herbicides / pesticides / insecticides commonly used in the area.
6. Estimation of Ecological indices:
 - i) Index of diversity, richness,
 - ii) Evenness and dominance of species.
7. Calculation of similarity & dissimilarity index between two adjoining communities.
8. Calculations of Niche overlap between two species.
9. Survey of local market for studying vegetable diversity.
10. Visit to plateaus, grasslands, forests to understand plant diversity.
11. Visit to local fish market for identification.

INTERNAL EVALUATION 30 MARKS

(viva-voce + journal + data evaluation)

Reference books:

1. Simpson, G.G. (1949). *The meaning of evolution, A Study of the History of Life and of Its Significance for Man*. Oxford University Press.
2. Magguran, A.E. (1996). *Ecological diversity and its measurements*. Princeton University.
3. Gadgil, M. () *A methodology manual for scientific inventorying, monitoring and conservation of Biodiversity*.
4. Sutherland, W. (2006). *Ecological census technique: A Handbook, 2nd Edn*. Cambridge University Press.
5. Gadgil, M. et. al. *A Methodology Manual for Documenting People's Priorities for Biodiversity and Conservation. Shrustiygyaan*.
6. Malhotra, K.C. et. al. (2001). *Cultural and Ecological Dimensions of Sacred Groves in India*. INSA, New Delhi.
7. Gadgil, Madhav and Rao, P.R.S. *Nurturing Biodiversity: An Indian Agenda*. Centre for Environment Education, Ahmadabad, India. 1999.
8. Dobson, A.P., 1996, *Conservation and Biodiversity*. Scientific American Library, New York, NY.
9. Gaston, K J. and J.I. Spicer, 1998, *Biodiversity: An Introduction*. Blackwell Science, London, UK.
10. Loreau, M., and P. Inchausti, 2002, *Biodiversity and Ecosystem functioning: Synthesis and Perspectives*. Oxford University Press, Oxford, UK.
11. Primack, R.B., 2002, *Essentials of Conservation Biology*, 3rd Edn., Sinauer Associates, Sunderland, Ma. USA.
12. Hunter, Malcolm L., Jr., and Gibbs, James P. *Fundamentals of Conservation Biology*. 3rd ed. Wiley-Blackwell. 2006

EST-202: Water and Wastewater Engineering

Marks: External 70

Internal 30

Unit	Topic	Credit	Lectures
UNIT-1	Water: Water requirement - domestic, institution, firefighting, commercial, industrial and cultural places, consumption, population forecasting - demographic, arithmetical progression, geometrical progression and logistic method, BIS, WHO standards for drinking and package drinking water.	1	14

UNIT-2	Water Treatment: Physical Units- Principles, applications and designing aspects of - Bar screen, grit chamber, bar munits, skimming tanks Chemical Units - Principles, applications and designing aspects of - Coagulation and Sedimentation, flocculation, disinfection, clarifier.	1	14
UNIT- 3	Biological Units: Aerobic treatment- Principles, applications and designing aspects of - Activated Sludge Process, Aerobic ponds, Oxidation ponds, Stabilization ponds Anaerobic treatment- Principles, applications and designing aspects of - Trickling filter, Rotatory Biological Contactors (RBC's), Continuous Stirring Tank Reactor, UASB, Fluidized Bed Reactor	1	14
UNIT-4	Advanced treatment Wastewater: Ultra filtration, Nano-filtration, Reverse Osmosis, Wet Air Oxidation, ozonization, PACT, ion exchange, Membrane bioreactor, Green Technology- Bioremediation Sludge: Composting, land filling, thickening, alkaline stabilization, Conditioning, incineration, Dewatering.	1	14

INTERNAL EVALUATION 30 MARKS
(seminar+term paper+test)

PRACTICAL ESP -205 based on EST- 202
WATER AND WASTEWATER ENGINEERING

Marks: External 35

Internal 15

1. Determine sludge volume index of given wastewater sample
2. Determine MLSS of given wastewater sample
3. Determine MLVSS of given wastewater sample
4. Determine oil and grease of given wastewater sample
5. Study of Jar test for wastewater treatment
6. Determine nitrate concentration in given wastewater sample
7. Determine phosphate in given wastewater sample
8. Determine sulphate in given wastewater sample.
9. Visits to industries, water treatment plant and sewage treatment plant.

INTERNAL EVALUATION 30 MARKS
(viva-voce + journal + data evaluation)

Reference books:

1. Wastewater Engineering: B.C.Punmia and Ashok Jain. Laxmi Publication N.Delhi
2. Water and Wastewater Enginnering : G.S.Birdie and G.S.Birdie
3. Water and Wastewater Enginnering Vol.I: Garg and Garg
4. Water and Wastewater Enginnering: Metcalf and Eddy
5. Environmental Enginnering: R.S.Gidde
6. Water and Wastewater Enginnering: Arcivala
7. Water and Wastewater Enginnering : Mackenzie L Devis WEF Publication
8. Principles of Foundation Engineering : Braja M.Das

Subject Electives (any one)

EST – 203 (A) Remote Sensing and GIS in Environmental Science

Marks: External 70

Internal 30

Unit	Topic	Credit	Lectures
UNIT-1	Principles of Remote Sensing, History, Stages of Remote Sensing, Remote Sensing In India, Types of Remote Sensing, and Types of Resolution: Spectral, Spatial, Temporal, Radiometric, Spectral Signatures. Electro Magnetic Radiation, EM Spectrum, Energy Interaction with the Atmosphere and Earth Surface.	1	14
UNIT-2	Types of platform, Types of sensor and cameras, processes of sensor & its characteristics. Element of Image Interpretation: Tone, Color, Texture, Pattern, Shape, Size and associated features.	1	14
UNIT- 3	Definition, History, Objectives of GIS, components of GIS, Application of GIS. Types of Geographical Data: Raster Data Model, Vector Data Model, GIS Tasks: Input, Manipulation, Management, Query, Analysis and Visualization. Layer, Geographic Reference.	1	14
UNIT-4	Types of data: Spatial Data, Non Spatial Data, Level of measurement: Nominal, Ordinal, Interval, Ratio. Definition, Advantages of Topology, Concept of Arc, Node and Vertices, Connectivity, Containment, Contiguity.	1	14

INTERNAL EVALUATION 30 MARKS

(Seminar + term paper + test)

PRACTICAL ESP -206 based on EST- 203A

REMOTE SENSING AND GIS IN ENVIRONMENTAL SCIENCE

Marks: External 35

Internal 15

1. Satellite Referring Scheme (Digital) and Browsing Satellite Data (from NRSC/GLCF/Glovis).
2. Familiarization with DIP s/w, Image Display
3. Image Rectification, Enhancement and Registration.
4. Image Classification: Supervised and Unsupervised.
5. Accuracy Assessment.
6. Field Work (GPS Demo and Image Interpretation).
7. Familiarization with GIS Software and Geo-referencing.
8. Spatial data entry, Editing, Topology creation and Layout preparation.

INTERNAL EVALUATION 30 MARKS

(viva-voce + journal + data evaluation)

Reference Books:

1. Fundamentals of Remote Sensing: George Joseph
2. Remote Sensing and Image Interpretation: Lillesand & Keifer.

3. Remote Sensing Principles and Interpretation: F.F. Sabins.
4. Introduction to Remote Sensing: J.B. Campbell.
5. Concepts and Techniques of Geographic Information Systems CP Lo Albert K W Yeung, 2005 Prantice Hall of India.
6. Principles of GIS for Land Resources Assessment by P.A. Burrough, Oxford : Science publications, 1986.
7. Geographic Information Systems – An introduction by Tor Bernhardsen, John Wiley and Sons, Inc, New York, 2002.
8. GIS – A computing Perspective by Micheal F. Worboys, Taylor & Francis, 1995.
9. Remote Sensing and Image Interpretation by Thomas M. Lillesand and Ralph W. Kiefer, John Wiley and Sons Inc., New York, 1994.

EST-203 (B): Analytical Techniques and Instrumentation

Marks: External 70

Internal 30

Unit	Topic	Credit	Lectures
UNIT-1	Electrochemical Methods Principles and applications: pH meters, Ion selective electrodes, Conductivity Meters, Gravimetric Methods-TS,TSS,VSS High Volume Sampler, Scrubber, Electrostatic Precipitator, Bag Filter, Incinerator.	1	14
UNIT-2	Photometric methods Principles and applications: Nephelometry and Turbidometry Spectrophotometer, UV Visible – Spectrophotometer, Flame photometry (FP), Atomic Absorption Spectrophotometry, Nuclear Magnetic Resonance (NMR), X-ray Fluorescence, X-ray Diffraction.	1	14
UNIT- 3	Chromatography- Principles and applications: Gas liquid chromatography, GC-MS &- High Performance Liquid Chromatography (HPLC), Inductively Coupled Plasma Spectroscopy (ICP), Aerosol Time of Flight Mass spectrophotometry (ATOMFS).	1	14
UNIT-4	Dosimetry: Geiger Muller Counter & Scintillation counter Electrophoresis: Gel electrophoresis & Immuno electrophoresis (ELISA, RFLP) Microscopy: Light microscope, - Fluorescent microscope Transmission Electron Microscope (TEM) and Scanning Electron Microscopy (SEM) Micrometry: Micro techniques- Fixation, Sectioning, Histological and Histochemical staining.	1	14

INTERNAL EVALUATION 30 MARKS
(seminar+term paper+test)

PRACTICAL (minimum eight) ESP -206 based on EST- 204 (A)
ANALYTICAL TECHNIQUES AND INSTRUMENTATION

Marks: External 35

Internal 15

1. Determination of pH and EC of water and wastewater samples

2. Determine SPM concentration from the ambient air
3. Determine SOX concentration from the ambient air
4. Determine NOX concentration from the ambient air
5. Determination of Calcium by flame photometer
6. Determination of Sodium by flame photometer
7. Determine _ max of cobalt and nickel solution by spectrophotometer
8. Examine microscopic structure of xerophytes / mesopyhtes stem
9. Examine and prepared a permanent slide of plant (Stem/ Leaf) by using staining.
10. Visit to Central Facility Centre (XRD, XRF, NMR,AAS, GC-MS and UV spectrophotometer).

INTERNAL EVALUATION 30 MARKS

(viva-voce + journal + data evaluation)

Reference books:

1. Environmental Chemistry : Moore and Moore Wiley's Publication
2. Environmental Chemistry : A.K. De
3. Environmental Chemistry : S.J.Arnika
4. Text Book of Environmental Chemistry and Pollution Control : S.S.Dara
5. Instrumental method Analysis: G.W.Ewing
6. Instrumental method Analysis: Chatwal Anand
7. Environmental Pollution Analysis: S.N. Khopkar

Open Electives (any one)

EST 204(A) – Hydrogeology

Marks: External 70

Internal 30

Unit	Topic	Credit	Lectures
UNIT-1	Introduction, Scope of Hydrogeology.(01), Hydrologic cycle : Types of Precipitation (02), Evapotranspiration (01), Initialization, Run off, Age of groundwater and classification of groundwater (01), Darcy law and its range of validity (02), Hydraulic conductivity methods of determination of hydraulic conductivity, Hydrostrigraphic units (03),Hydraulic conductivity for an anistropic aquifer (01), Groundwater movement and tracer technique (01),Groundwater equations for steady and unsteady flow. (02)	1	14
UNIT-2	Occurence of groundwater : Types of openings in the rocks (01) Groundwater in Granitic, Basaltic, Metamorphic, Lime stones, Alluvium (unconsolidated sedimentary), Sandstones and Shale (03) Porosity, permeability, specific yield, specific retention, transmitivity storage coefficient (definitions and methods of determination) (03) Hydrographs, Water-table and piezometric level contour maps construction and interpretation (04) Well hydraulics : Determination of aquifer characteristics from pump tests (Thies,Thesis,Chow's Cooper Jacobs, Ruston and Singh, Recovery method etc.) (04)	1	14

UNIT- 3	Fresh and saltwater relationship in coastal area and islands (01), Ghyben – Hergberg principal and its modification, prevention and control of sea water intrusion (02), Groundwater provinces of India (01) Introduction to various methods of prospecting and exploration of groundwater Geological (01) Geophysical (01), Remote sensing (01), Consumptive and Conjunctive use of surface and groundwater (02), Types of confining layers (01), Types of Aquifers (02), Basic ideas of groundwater development and management (02)	1	14
UNIT-4	Artificial recharge methods and structures (03) Water logging problems (02) Problems of over exploitation (02) Groundwater legislation (01) Assessment of groundwater quality (02) Geochemistry of groundwater (02) Computer application in Hydro geological studies (02)	1	14

INTERNAL EVALUATION 30 MARKS

(Seminar + term paper + test)

PRACTICAL ESP -206 based on EST- 203(B)

Hydrogeology

Marks: External 35

Internal 15

Preparation and interpretation of Hydrogeological maps.

Computation of Hydraulic Gradient.

Groundwater flow maps and flow net analysis, problem related to Darcy's law .

Analysis of well inventory data, pump test analysis, field techniques and computation of aquifer parameters

by different methods.

Use of well logging techniques.

Application of computer programs in solving groundwater problems.

Reference Books:

1. Groundwater, Todd, D.K., John Wiley.
2. Hydrogeology, Davies, S.N. & Dewiest, R.J.M. John Wiley.
3. Groundwater, Freeze, R.A. & Cherry, J.A., Prentice Hall.
4. Applied Hydrogeology, Fetter, C.W. , Merrill publishing.
5. Groundwater, Raghunath, N.M. Wiley Eastern.
6. Groundwater assessment-development and management. Karanth, K.R. Tata McGraw Hill.
7. Regional Groundwater quality, Alley, W.M., VNR, New York.
8. Water. Subramaniam. V, Kingston Publ. London.
9. Groundwater and Tubewells, S.P. Garg, CBS Publication.
10. F. M. Introduction to Groundwater Hydrology,
11. Theory of Aquifer tests USGS, Wisler, C.P and Brater E. F.
12. Chow V. T. (edi) Hand book of Applied Geology.
13. Ground water Resource and Evaluation, Walton, W. C.
14. David k. Todd and Larry W. Mays , Ground water hydrology, 3rd edition, Wiley India.

EST 204 (B) Oceanography and marine biology

Marks: External 70

Internal 30

Unit	Topic	Credit	Lectures
UNIT-1	Earth structure and interior, Plate tectonic theory, Basic concept of ocean and sea, origin of ocean basins, Ocean floor topography, bathymetry, ocean waves and currents, coastal geomorphology, seawater composition.	1	14
UNIT-2	Ocean circulation and conveyor belt, El-nino and La-nina phenomena, sea level rise, Tsunami, formation of delta, Case study: Sundarban , volcanic vents on the sea floor	1	14
UNIT- 3	Life in ocean- Photosynthesis in ocean, ocean ecosystem, marine environment with distinct zones, ocean habitats, coral reef, estuary, marine resources, pelagic community and benthic community, role of mangrove, Coastal zone	1	14
UNIT-4	Marine pollution and its impact on biotic component, control of marine pollution, oil spill, plastic pollution in ocean. Ocean acidification, Use of remote sensing in marine science, ocean as source of energy, coastal regulation zone.	1	14

INTERNAL EVALUATION 30 MARKS

(Seminar + term paper + test)

PRACTICAL ESP -206 based on EST- 203(A) & Open electives

Practical: Oceanography and marine biology

1. Water sampling of seawater.
2. Study of phytoplankton and zooplankton of seawater.
3. Study of estuary or coastal wetland.
4. Physical and chemical analysis of seawater.
5. Study of coast and its vegetation.
6. GIS in coastal management
7. study of impact of pollution on ocean eg. ballast water, sewage etc.
8. Field visit to marine species habitat.

References:

1. Introduction to Marine Biology (with InfoTrac) (Available Titles CengageNOW) 2nd Edition by George Karleskint , Richard Turner , James Small
2. Essentials of Oceanography 7th Edition by Tom S. Garrison
3. Essentials Of Oceanography Paperback (English) 11th Edition by Trujillo A.N., Thurman H.V.,
4. Remote sensing and image interpretation (2nd edn), 1987 –Lillesand, T.M. and Kiefer, R.W., John Wiley and sons.
5. Marine Biology by Peter Castro.
6. Marine Biology 8th Edition by Peter Castro ,Michael Huber
7. An Introduction to Ocean Remote Sensing 2nd Edition by Seelye Martin, Cambridge university press.

PART- II
SEMESTER – III

EST-301: ENVIRONMENTAL POLLUTION

Marks: External 70

Internal 30

Unit	Topic	Credit	Lectures
UNIT-1	<p>a)Air pollution: Concept of air pollution, natural and anthropogenic sources, major air pollutants, Meteorological aspects of air pollution, Oxides of nitrogen and sulphur, particulate matter, air pollution standards, Indoor air pollution, Vehicular air pollution, air pollution episodes and disasters, Effects of air pollution on human health, animals, plants, material and climate. Formation of fog and photochemical smog, acid rain, Monitoring of air pollution.</p> <p>b) Noise Pollution: Concept of noise, sources of noise, measurement of noise, religious festival and noise, Noise exposure levels and standards, effects noise on plants animals and human beings, control of noise at source, industrial noise control, prevention of community noise control.</p>	1	14
UNIT-2	<p>Water Pollution: Principal forms of water pollution, sources of water pollution, phenomenon of eutrophication, water pollution monitoring, physicochemical and bacteriological sampling and analysis of water, water quality parameters, water quality standards, ocean pollution sources of pollution, effects, control. Thermal pollution, Oil pollution sources of pollution, effects, control, ground water pollution - sources of pollution, effects, control, water pollution episodes, consequences of water pollution, water pollution prevention.</p>	1	14
UNIT- 3	<p>Soil Pollution: Importance and types of soil, concept of soil pollution, analysis of soil key parameters, soil acidity, saline and alkaline soil., causes of soil salinity, major types, physicochemical and biological methods of soil reclamation, Different causes of soil degradation, Chemical and metallic pollution in agricultural soil, Mining and soil pollution, Control of soil pollution.</p>	1	14
UNIT-4	<p>a) Solid Waste Pollution: Concept and types of solid waste, Major sources of solid waste, effects of solid waste classification of waste. Domestic, Industrial, Municipal, Hospital, Nuclear, E-waste and Agriculture waste. Transfer and transport, waste minimization technologies -recycle, reuse, recovery, conversion of solid waste to energy / manure, sea disposal, incineration, compost and land disposal.</p> <p>b) Radiation Pollution: Types, sources- natural and manmade, Measurement and detection of radiation intensity, consequences of radiation life, coefficient units for measurement of radiation,</p>	1	14

	control of radiation pollution., Nuclear reactor safety, case studies.		
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(Seminar + term paper + test)

PRACTICAL (minimum eight) ESP – 305 based on EST – 301

ENVIRONMENTAL POLLUTION

Marks: External 35

Internal 15

1. Study of Air micro flora
2. PM 10 and PM 2.5 measurement by Find Air Dust Sampler
3. SO_x and NO_x measurement by Find Air Dust Sampler
4. Measurement of Noise by Noise Level Meter
5. Calculation of Noise levels from different locations
6. Estimation of chlorophyll, polyphenol and vanadium from affected plant leaves
7. Estimation of Total Hardness from provided water sample
8. Determine MPN from water samples
9. Determination of Primary production by light and dark bottle technique
10. Physical composition of solid waste / refuse
11. Physical characterization of solid waste / refuse
12. Construct the composting pit and vermiculture
13. Estimation of WHC, Soil texture and soil profile
14. Study of physico-chemical parameters of soil

Reference books:

1. Environmental Pollution Control, C.S. Rao, Wiley Eastern Ltd.,1993
2. Air Pollution Control and Engineering, De Nevers, Mc Graw? Hills, 1993
3. Fundamentals of Environmental Pollution, Krishnan Khannan S.Chand & Company Ltd.,1994.
4. Environmental Chemistry, A. K. De., New Age Intl. pub Co, New Delhi, 1990
5. Ground water contamination (Transport and remediation), Philp Bedient, Hanadi. S. Rifai and Charles. Publishers: Prentice Hall.
6. Environmental Science, S.C. Santra , 2014.
7. Environmental Pollution Control, C.S.Rao, Wiley Eastern Ltd.,1993
8. Air Pollution Control and Engineering, De Nevers, Mc Graw Hills, 1993
9. Fundamentals of Air Pollution, Samuel, J.W., 1971, Addison Wesley Publishing
10. Fundamentals of Environmental Pollution, Krishnan Khannan S.Chand & Company Ltd.,1994.
11. Noise Pollution,Vandana Pandey, Meerut Publishers,1995

EST-302: ENVIRONMENTAL BIOTECHNOLOGY

Marks: External 70

Internal 30

Unit	Topic	Credit	Lectures
UNIT-1	Microbial Environment Nature and function of micro-organisms in soil, water and air, Environmental Significance of Bacteria, Fungi, and Algae, Microbial Metabolism, Growth and Bio-kinetics Structure and Functions of Procaryotic Cells & Eucaryotic Cells, Microbial Nutrition and Metabolism, Microbial Growth and Energy, Effect of Environment on Enzyme activity, Microbial Growth and Substrate	1	14

	Utilization Kinetics.		
UNIT-2	Environmental Biotechnology Scope of environmental biotechnology; Basics of RDT, GEM, Biodegradation of macromolecules; Degradation of xenobiotic compounds-Simple, aromatic, chlorinated, polyaromatic hydrocarbons, heavy metals, petroleum products, pesticides and surfactants. Genetically modified microorganisms types and applications.	1	14
UNIT- 3	Biopesticides: Historical background, Antagonism, Amensalism, competition, predation and parasitism, Biofertilizer for bio control: Vegetative part and soil inoculation, mycorrhizal fungi. Microbial pesticide: Bacterial pesticide, Mycopesticide, transgenic plant, Mycoherbicide, insect as bio control.	1	14
UNIT-4	Bioremediation Soil Environment: Biotechnologies for Ex-Situ and In Situ Remediation of Soil, Bioleaching, biosorption and oil degradation, creation of superbug, Phytoremediation Technology for Soil Decontamination, Sequestering Carbondioxide. Air Environment: Biological Filtration Processes - Air Stream, Biofiltration, Biotrickling Filtration and Bioscrubbers. Water Environment: Ex-situ and In situ Decontamination of Groundwater, Bioaugmentation, Landfill Leachate Biotreatment. Biotreatment of Metals: Microbial Transformation of Metals, Bioleaching and Biobenificiation Bioaccumulation Oxidation/Reduction Processes, Biomethylation, Biomonitoring.	1	14

INTERNAL EVALUATION 30 MARKS
(seminar+term paper+test)

PRACTICAL (minimum eight) ESP – 305 based on EST – 302
ENVIRONMENTAL BIOTECHNOLOGY

Marks: External 35

Internal 15

1. Aseptic techniques:
 - I. Safe handling of Microbes
 - II. List of cultures
 - III. Preparation of Culture media
 - IV. Preparation of slant, butt and plate
 - V. Transferring of culture
 - VI. Establish pure culture by streak plate method
 - VII. Storage of culture
2. Differential (Gram's) staining
- 12
3. Study of Growth curve
4. Preparation of azofertilizers

5. Preparation of rhizofertilizers
6. Isolation of bacteria from Air
7. Isolation of Fungi from Air
8. Design of root zone bed for bioremediation
9. Sampling of aquatic weeds for bioremediation

Reference books:

1. Introduction to Environmental Biotechnology, A.K.Chatterji, Prentice Hall of India Pvt. Ltd, New Delhi
2. Environmental Biotechnology-Basic Concepts and Applications Indu Shekhar Thakur I.K. International Pvt. Ltd. New Delhi.
3. Environmental Biotechnology S.K. Agawal, APH Publishing Corp., New Delhi.
4. Elements of Biotechnology, P.K.Gupta, Rastogi Publishing House, New Delhi.
5. Environmental Biotechnology ,Jogdand S.N., Himalaya Publishing House, New Delhi
6. Biotechnology, B.D.Singh, Kalyani Publishers , New Delhi
7. Molecular Biotechnology- Principles and Applications of Recombinant DNA, Glick and Pasternak. Panima Publishing Corporation, New Delhi
8. A Text Book of Biotechnology, R.C. Dubey, S. Chand & company Ltd., New Delhi

Subject Electives (any one)
EST- 303A: Environmental Statistics

Marks: External 70

Internal 30

Unit	Topic	Credit	Lectures
UNIT-1	Statistical sampling, purpose of sampling, principles of sampling, merits of sampling, basics and types of samplings, simple random sampling, Stratified random sampling, Systematic sampling, Multistage sampling. Statistical methods for environmental systems, Types of data, methods of collection of primary and secondary data, methods of data presentation, graphical representation by histogram, polygon, ogive curves, pie diagram etc.	1	14
UNIT-2	Measures of central tendency and their properties -mean and its types, median, mode, Measures of dispersion-Variance, Standard Deviation, Mean Deviation, Coefficient of Variation, range and quartile deviation, concept and types of skewness and kurtosis, moments. Concept of probability, addition and multiplication theorem of probability, conditional probability and unconditional probability, Simple problems on probability.	1	14

UNIT- 3	Concept and types of hypothesis, Sampling theories and Hypothesis testing, null and alternative hypotheses, tests of hypothesis- t test, f test, z test and Chi-square tests, Sampling techniques and experimental designs. Testing hypothesis: Significance level and X2 test, t and F test Variables of environmental interest.	1	14
UNIT-4	Concept of Correlation, its types and application in environmental Science, Concept of Regression lines-x on y and y on x, regression analysis, large sample list for mean, proportions equality of means. Multivariate data structure, PCA, DCA, cluster analysis, CCA, types of analytical algorithms	1	14

INTERNAL EVALUATION 30 MARKS

(Seminar + term paper + test)

PRACTICAL ESP / 306 based on EST – 304

Environmental Statistics

Marks: External 35

Internal 15

Data collection and their types.

Measure of central tendency – Mean, Mode and Median

Dispersion

Models

Hypothesis

Probability

Regression

Reference Books:

1. Campbel, R.C., (1974), Statistics for Biologist, Cambridge University Press, UK.
2. Ford, E.D. 2000, Scientific methods for Ecological Research. Cambridge University Press, Cambridge.
3. Rosner, B. (1986), Fundamentals of Biostatistics, Duxbury Press, Boston.
4. Zar, J.H. (1984), Biostatistical Analysis. Prentice-hall, Inc Englewood Cliff, New Jersey.
5. Snedecor, W and G. Cochran, (1967), Statistical Methods. Oxford and IBH Publishing Co. Calcutta.
6. Bodkin, Daniel D. (1995), Environmental Science- Earth As a Living Planet, John Wiley & Sons, New York.
7. Gore, Anil and Paranjpe, S.A. (2000), A Course on Mathematical and Statistical Ecology, Kluwer.
8. Ludwig, J.A. and Judwig, J.F. (1988), Statistical Ecology, Wiley and Sons, New York.
9. S. E. Jorgeson (1994), Fundamentals of Ecological Modelling, Levis Publications, New York.
10. Pielou, E.C. (1997), An Introduction to Mathematical Ecology, John Wiley and Sons, New York.
11. Sen, A. (1997), Poverty and Inequality, Oxford University Press, Oxford.
12. Smith, J. M. (1982), Evolution and the Theory of Games, Cambridge University Press, Cambridge.

EST 303 B: Digital image processing

(Marks: External 70)

Internal 30

Unit	Topic	Credit	Lectures
UNIT-1	Recent Trends In GIS Recent Trends: Location Based Services, Virtual Reality GIS, Enterprise Resource Planning, SAP ERP. Internet and GIS: Introduction, History, Services, Open Geospatial Consortium (OGC), Geographic Markup Language (GML), Keyhole Markup Language (KML), Web Map Services.WEB GIS.	1	14
UNIT-2	Decision Support System (DSS) Introduction, Process of Decision Making, Types of Problems, Characteristics of DSS, Efficiency and Effectiveness of Decision Making, Architecture of A DSS, DSS and Expert System. Multicriteria Decision Analysis Introduction, Components, Estimation of Weights: Trade off Method, Rating Method, Ranking Method, Weighted Summation, Paired Comparison.	1	14
UNIT- 3	Surface Analysis & decision making models Interpolation Method, Dem, Tin, Variance Filter, Slope and Aspect, Relief And Hill Shading. Fuzzy Logic, Operation On Fuzzy Set Fuzzy Vs. Boolean, Basic Rules Of Inference, Artificial Neural Network.	1	14
UNIT-4	Spatial Data Mining Method of Knowledge Discovery In Spatial Database, Spatial Mining Tasks: Spatial Classification, Spatial Clustering, Association Rules.	1	14

INTERNAL EVALUATION 30 MARKS
(seminar+term paper+test)

PRACTICAL ESP – 307 based on EST – 305

ADVANCED TECHNIQUES IN GIS

(Marks: External 35)

Internal 15

- 1 Interpolation: IDW, Kriging
- 2 Surface Analysis: DEM, Slope, Aspect, Contour, Hillshade, Viewshade
- 3 Visual Interpretation Techniques of Image
- 4 Multi Criteria Analysis In Arc GIS
- 5 Site Suitability Analysis

Reference Books:

- GIS and Multi-criteria Analysis by Makrewski Jacek, USA, 1999.
- Principals of GIS by Burrough P.A. MacDonneli R.A. published by Oxford University Press, 2000.
- Expert Systems and Applied Artificial Intelligence, E. Turban, Macmillan, 1992
- Introduction to Expert Systems, Peter Jackson, Harlow, England: Addison Wesley Longman, 1999.
- Neural networks: A comprehensive Foundation, Simon Haykins, Prentice Hall Inc., 1999.
- Fuzzy sets, uncertainty and information, Geroge J. Klir, Tina A. Folger, Prentice Hall

inc., 2000.

- Genetic Algorithms in Search, Optimization, and Machine Learning, Goldberg, David Edward, Addison-Wesley Pub. Co., 1989
- Genetic Programming: On the Programming of Computers by Means of Natural Selection, J. Koza, The MIT Press, 1992.

One Open Elective

EST- 304(A): RESEARCH METHODOLOGY FOR DISSERTATION

Marks: External 70

Internal 30

Unit	Topic	Credit	Lectures
UNIT-1	Basic concepts: Meaning, Objectives, Motivation and Approaches. Nature of Scientific Inquiry, science and logic, Types of Research Descriptive, Analytical, Applied, Fundamental, Quantitative, Qualitative, Conceptual, and Empirical. Research methods and methodology, Research Process.	1	14
UNIT-2	Research formulation: Observation and Facts, Prediction and explanation, Induction, Deduction. Defining and formulating the research problem, Literature review - Importance of literature reviewing in defining a problem, Critical literature review, and Identifying gap areas from literature review. Sampling Design and Sample Size; Concept of Hypothesis Testing.	1	14
UNIT- 3	Research Design and its types; Methods of Data Collection, Sources of Data Collection- Use of Secondary Data and Methods of Collecting Primary Data, Observation and Interviews, Questionnaires and Schedules. Need for Multi- Disciplinary and Inter-Disciplinary Research.	1	14
UNIT-4	Writing the Research Report (Dissertation, publications, patents): Components of research report - Title, Authors, Addresses, Abstract, Keywords, Introduction, Materials and Methods, Results, Discussion, Summary, Acknowledgements and Bibliography. Use and availability of Internet resources for research, search engines and using advanced search techniques.	1	14

INTERNAL EVALUATION 30 MARKS

(Seminar + term paper + test)

PRACTICAL ESP –306 based on Open Electives [EST – 304(A)]

RESEARCH METHODOLOGY

Marks: External 35

Internal 15

1. Study of drainage patterns.
2. Determination of contour intervals and profile.
3. Determination of drainage density.
4. Study of water holding capacity.
5. Study of wilting coefficient.
6. Estimation of peak runoff.

7. Estimation of soil erosion.
8. Studies based on bund geometry.
9. Demarcating contour intervals on the field.

Reference Books:

1. Montgomery, Douglas C. (2007), 5/e, Design and Analysis of Experiments, (Wiley India).
2. Montgomery, Douglas C. & Runger, George C. (2007), 3/e, Applied Statistics & Probability for Engineers (Wiley India).
3. Clough, P. and C. Nutbrown. 2002. *A Student's Guide to Methodology: Justifying Enquiry*. Sage, London.
4. Dharmapalan, Biju. 2012. *Scientific Research Methodology*. Narosa Publishing House, New Delhi.
- 18
5. Kothari C.R., 2009. *Research Methodology: Methods and Techniques* (2nd edn.). New Age International Publishers, New Delhi.
6. Paul Oliver. 2005. *Writing Your Thesis*. Vistaar Publications. New Delhi.
7. Ahuja, V.K. 2010. *Law of Copy Rights and Neighbouring Rights : National and International Perspectives*. Lexis Nexis- Butterworths Wadhwa, Nagpur.
8. Research Methodology – Text and Cases with SPSS Applications, by Dr S.L. Gupta and Hitesh Gupta, International Book House Pvt Ltd.

EST – 304(B): Meteorology

Marks: External 70

Internal 30

Unit	Topic	Credit	Lectures
UNIT-1	Basic concepts, scope and importance of Meteorology, concept of weather and climate. Atmospheric composition, structure of atmosphere, atmospheric stability, Koeppen's scheme of classification of climate, types of precipitation (rainfall, hailstorm etc)	1	14
UNIT-2	Meteorological parameter eg. Rainfall, pressure, wind speed, humidity, temperature, sunshine etc. types of cloud and its formation, Atmospheric circulation, Inter Tropical Convergence Zone (ITCZ), Energy transfer within the earth-atmosphere system	1	14
UNIT-3	Heating Earth's Surface and Atmosphere, Tropical and polar climate, The South Asian monsoon, <i>Winter, Spring, Early summer, Summer, Autumn</i> . Indian monsoon, Optical Phenomena of the Atmosphere	1	14
UNIT-4	Atmospheric radiation, meteorological disaster (cyclone, tornado, hurricane), Lightning, dust storm, Green house gas effect, global warming, climate change, natural causes of climate change, human impact on climate change, ozone hole formation, Remote sensing in climatic studies	1	14

PRACTICAL EST / 306 – EST303A/B & EST 304B Open Electives

Meteorology Practicals:

1. Identification of clouds.
2. Collection and interpretation of meteorological data.
3. Visit to weather station.
4. introduction of Remote sensing software in meteorology.
5. study of drought : a case study.
6. study of flood prone zone: a case study.
7. Use of computer in climatology.
8. study of polar plot and graphs in meteorology.

References:

1. The atmosphere : an introduction to meteorology by Lutgens & Tarbuck.
2. Atmosphere, Weather and Climate by Roger G. Barry and Richard J. Chorley
3. An Introduction to Physical Geography and the Environment by Joseph Holden
4. Earth science, Geology, the environment and the universe by Francisco Borrero, Frances Scelsi Hess , Juno Hsu Gerhard Kunze , Stephen A. Leslie , Stephen Letro Michael Manga , Len Sharp , Theodore Snow , Dinah Zike, National Geographi.

PART- II SEMESTER – IV
EST 401: ENVIRONMENTAL POLICY, ACTS, LAWS AND ENVIRONMENTAL
MANAGEMENT SYSTEM

Marks: External 70

Internal 30

Unit	Topic	Credit	Lectures
UNIT-1	<p>Environmental policy: International and Government of India's policies in the protection of environment, Environment action plan National Forest Policy, 1989, National Water Policy, 2002.</p> <p>Policy statement: Introduction, problems, objectives and future directions, Constitutional provision regarding Environmental Protection (article 48 and 58 A).</p>	1	14
UNIT-2	<p>Environmental Conferences: Stockholm Conference (UNCHE); Montreal Protocol; UN conference on environment and development, Rio (UNCED) Summit; Population conference, Cairo and climatic change conference, Kyoto; International union for conservation of nature and natural resources (IUCN); UN environmental programmers (UNEP); World-wide fund for nature (WWF).</p>	1	14

UNIT- 3	Environmental laws in India: The Factories Act, 1948 and Amendment thereof, The Water (prevention and control of pollution) Act, 1974; The Forest (conservation) Act,1980; The Air (prevention and control of pollution) Act,1981; The Environment (protection) Act,1986, Public Liability Insurance Act,1991, The Wildlife (protection) Act,1972. Biodiversity Act, 2002.	1	14
UNIT-4	Environmental Management: Environmental Monitoring, Environmental Modelling, Principles of Environmental Management, Definition and Scope, Ethics and Environment, Application of Remote Sensing and GIS in Environmental Management.	1	14

INTERNAL EVALUATION 30 MARKS
(Seminar + term paper + test)

PRACTICAL ESP – 405 based on EST – 401

ENVIROMENTAL POLICY, ACTS, LAWS AND ENVIRONMENTAL MANAGEMENT SYSTEM

Marks: External 35

Internal 15

1. Case Study on Air Pollution
2. Case Study on Noise Pollution
3. Case Study on water Pollution
4. Case Study on Solid-waste Pollution
5. Case Study on Hazardous Waste
6. Case Study on Biomedical waste
7. Case Study on Sardar Sarovar
8. Case Study on Tehri Dam
9. Case Study on Silent valley

Reference books:

1. Environmental Laws of India - An Introduction: CPR Environmental Education Centre, Chennai (2001).
14
2. Introduction to Social Forestry : Sitram Rao, Oxford and IBH Pub. Co. Pvt. Ltd.
3. An Introduction to Environmental Management : Dr. Anand S. Bal, Himalaya Publishing House (2005).
4. Environmental Pollution – Management & Control for Sustainable Development : R. K. Hitoliya, S.Chand and Co.Ltd.New Delhi (2004).
5. Environmental Science : S. C. Santra, New Central Book Agency, Kolkata, 2005
6. Environmental Law and Policy in India: Divan S and Rosencraz A,Oxford University Press, New Delhi. (2001)
7. Labour and Industrial Law: Sing, A, K. and Agrawal R. K., Pioneer Printers, Agra (2000).
8. Environmental Policies: Sinha P. C., Anmol Publications Pvt. Ltd, New Delhi (1998).
9. Environmental Guidelines and Standards in India:Goel P. K and Sharma K. P, Techno Science Publications, Jaipur (1996).

EST 402: ENVIROMENTAL TOXICOLOGY AND SAFETY

Marks: External 70

Internal 30

Unit	Topic	Credit	Lectures
UNIT-1	Introduction to Environmental Toxicology: Definition, classification, Basic Concepts, origin of toxicants, general nature of toxicants in environment, Evaluation of toxicity, Bioassay, factors affecting toxicity, mutagenesis, spermatogenesis, carcinogens, hallucinogens, phytotoxins and animal toxins.	1	14
UNIT-2	Ecotoxicology: Routes of entry of toxicants, Toxic response of different body systems likes respiratory, gastro-intestinal tract, liver, kidney, immune system, reproductive System. Problems and approach, effects of toxicants on ecosystem, detoxification of Toxicants in resistant biota.	1	14
UNIT- 3	a. Environment, Health and Environmental stress: Basic principles of environmental health, community health, occupational health, impact of changing environment on biota, effect of stress on environment, adaptations and tolerance level of various organisms and stress factors, micro-organisms of extreme Environment. b. Bio-assay techniques: Study design protocols to evaluation of toxicants. Tests for assessing carcinogenicity and muta toxicity of compounds. TLC.	1	14
UNIT-4	General principles of safety: Need for safety humanitarian, sequence of accident occurrence occupational injuries-effects of industrial accidents, personal protective equipments. Legal and social consideration, role of management in industrial safety. Hazards in chemical plant-Material handling hazards – classification of hazardous chemical their storage and safe keeping, Hazardous waste handling & management rule 1989, Safety standards and codes. Safety policy-safety organization & responsibilities and authorities of different levels.	1	14

**INTERNAL EVALUATION 30 MARKS
(seminar+term paper+test)**

**PRACTICAL ESP – 405 based on EST – 402
ENVIRONMENTAL TOXICOLOGY**

Marks: External 35

Internal 15

1. Estimation of Lead (Pb)
2. Estimation of Mercury (Hg)
3. Estimation of Cadmium (Cd)
4. Estimation of Tin (Sn)
5. To Study the Effect of Temperature on bacterial Growth.
6. Study the Effect of PH on bacterial Growth.
7. Determination of LC 50
8. Determination of LD 50
9. Effect of H₂S on Plant material

10. Effect of NH₃ on Plant material
11. Effect of SO₂ on plant material

Reference books:

1. Water Toxicology: V. V. Metelev, A. I. Kanaev, N. G. Dzasokhova, Amerind Publishing Company, Pvt, Ltd, New Delhi (1971).
2. Water Pollution and Toxicology: S. K. Shukla & P. R. Srivastava, Commonwealth Publisher, New Delhi (1992).
3. Toxicology – Principles & Methods: M. A. Subramanian, MJP, Publishers, Chennai (2004).
4. Industrial Toxicology: Raymond D Harbison, A Times Mirror Company, 5th Edition, New Delhi (2006).
5. Environmental Science: S.C. Santra, New Central Book Agency, Kolkata (2001).
6. Environmental Pollution Health & Toxicology : S V S Rana, Narosa Publishing House, New Delhi (2006).
7. Environmental Science Hazardous Gas & Waste : R K Sinha, Commonwealth Publisher, New Delhi (1994).
8. Toxicology: P D Sharma, Rastogi & Company, Meerut (1995).
9. Industrial Safety and pollution control handbook:- National safety council, New Delhi.
10. Handbook of Environmental Health and Safety:- Herman Keren and Michal Biseis (1999).
11. Safety Evaluation of Environmental Chemicals: - T.S.S. Diksheth (1995).
12. Handbook of Environmental Risk Assessment and Management, Peter Calow (1998) Black well Science Ltd.

EST-403: ENVIRONMENTAL IMPACT ASSESSMENT AND ENVIRONMENTAL AUDIT
Marks: External 70 Internal 30

Unit	Topic	Credit	Lectures
UNIT-1	Environmental impact assessment (EIA): Definition of EIA and EIS, Environmental inventory, Concepts, scope and objectives of EIA; National Environmental Policy Act (NEPA, 1969); EIA guidelines-1994 (Notification of Government of India), Procedure to review report of Environmental impact assessment. Categories of NABET accreditation, Functional Areas.	1	14
UNIT-2	Impact assessment methodologies: Definition and concept of impact; Types of impacts (Negative & Positive: Primary & Secondary; Reversible and Irreversible; Tangible and Intangible); Impact identification; Methods for impact identification: Matrices, networks and checklists, Advantage & disadvantages of EIA methodologies.	1	14

UNIT- 3	<p>Components of EIA: Environmental Setting; Baseline data; Prediction and evaluation of impacts; Environmental management plan and monitoring, Baseline information, Prediction, evaluation and mitigation of impacts on socioeconomic, air water, soil and noise environment.</p> <p>Public participation in EIA: Decision making, Public participation in environmental decision making, Objectives and techniques for public participation, Advantages and Disadvantages of public participation.</p> <p>Preparation and writing of EIA: For water resources, Dams and irrigation projects; Mining and Infrastructural projects etc.</p>	1	14
UNIT-4	<p>Environmental Audit: Audit tools and technology, Procedure of environmental auditing Safety audit, Notification and guidelines for Environmental audit: Scope, applicability and objective of environmental audit, Environmental auditing in India, ISO 14001.</p>	1	14

INTERNAL EVALUATION 30 MARKS

(seminar+term paper+test)

PRACTICAL ESP – 406 based on EST – 403

ENVIRONMENTAL IMPACT ASSESSMENT & ENVIRONMENTAL AUDIT

Marks: External 35

Internal 15

1. Case study on EIA Mining,
2. Case study on EIA Irrigation Plant
3. Case study on EIA Thermal Power Plant
4. Case study on EIA Airports
5. Case study on EIA Highways
6. Case study on EIA Nuclear Power Plants
7. Case study on EIA Building Construction/ Townships
8. Case study on EIA Ports and Harbors

Reference books:

1. Handbook of Environmental Impact Assessment (Vol. I): Judith Petts, Blackwell Science, USA (1999).
2. Handbook of Environmental Impact Assessment (Vol. II): Judith Petts, Blackwell Science, USA (1999).
3. Methods of Environmental Impact Assessment: Peter Morris, Ricky Therivel, UGC Press Limited, London (1994).
4. Environmental Impact Assessment & Management: Daya Publishing House, New Delhi (1998).
5. Environment Impact Assessment: Larry W. Canter, Mc-Graw Hill Inc., New York (1996).
6. Introduction of Environmental Impact Assessment: John Glassion, Rikay Therival and A. Chadwick, UGC Press Ltd., London (1994).
7. A monograph on Environmental Audit: The Institute of cost and works Accounts of India, New Delhi (1994)
8. Using Environmental Management system to improve profits: B. Pearson, BFP Little and M. J. Brierley, Graham & Thotrman, Kluwer Academic Publisher Group, London (1992).

Subject Electives (any one)

EST- 404(A): DISSERTATION

Marks: External 70

Internal 30

INTERNAL EVALUATION 30 MARKS

(seminar+term paper+test)

Student will submit their independent dissertation work at the end of semester IV. Assessment of the dissertation and internship will be based on the submitted M. Sc. dissertation report, seminar and viva-voice examination.

PRACTICAL ESP – 406 based on EST – 404(A)

DISSERTATION

Marks: External 35

Internal 15

The Internship report submitted by the student and the evaluation report by the external supervisor.

EST – 404(B): ENVIRONMENTAL GEOLOGY AND DISASTER MANAGEMENT

Marks: External 70

Internal 30

Unit	Topic	Credit	Lectures
UNIT-1	Concept of ecosystem – biotic communities, food chain and Ecologic Pyramids. Impact of anthropogenic activities on air, water and soil resources. Their types, sources and causes of Pollutants, Controlling measures.	1	14
UNIT-2	Waste: Source and classification of waste products. Waste disposal and recycling methods. Control and management of waste materials. Impact assessment of anthropogenic activities such as urbanization, open cast mining and quarrying, disposal of mine and radioactive wastes, fly ash, use of fertilizers. Environmental protection – legislative measures in India.	1	14
UNIT- 3	Study of Natural Hazards like meteorite impact hazard, landslides, floods and drought, earthquakes, mining, volcanic eruptions: their classification, causes, assessment, prediction and controlling measures. Use of GIS and remote sensing in reduction of natural disasters. Preparedness for relief and recovery operations.	1	14
UNIT-4	Case histories of natural disasters of India viz. Koyana earthquake, Killari earthquake, UttarKashi earthquake, Uttarakhand floods, East coast cyclones, Tsunami, drought prone regions of India with special reference to Maharashtra.	1	14

INTERNAL EVALUATION 30 MARKS

(seminar+term paper+test)

PRACTICAL ESP – 406 based on EST – 404(B)

Environmental Geology & Disaster Management

Marks: External 35

Internal 15

Identification and mapping of natural hazards and zones and terminology of the associated features: viz, floods, landslides, glaciers, with the help of topographic sheets, aerial photographs and LANDSAT imageries.

Determination of pollutants from surface and subsurface water samples.

Assessment of the mining hazards with respect to case histories.

Classification of coastal zones and mapping.

Utilization of coastal environmental maps with the help of toposheets, aerial photographs and LANDSAT imageries.

World wide distribution of disasters.

Mapping of disaster prone zone with the help of remote sensing.

Study of case histories of natural disasters in India.

References books:

Environmental chemistry; A.K. De

Environmental Geology; Killer

Environmental Geology; Valdiya

Mineral economics : Sinha and Roy.

Mineral economics : Chatterjee.

Indian Bureau of Mines, Govt. of India.

Handbook of energy technology by V. Daniel Hunt.