Savitribai Phule Pune University
Final Year MSc (Environmental Sciences) (Colleges)
Revised Syllabus 2020

Semester	Course type	Course Code	Course Name	Credits
III	Core Compulsory Theory Paper	EVSUT 231	EIA & Environmental Audit	4
		EVSUT 232	Remote Sensing & GIS	4
		EVSUT 233	Restoration Ecology & Watershed Management	4
	Core Compulsory Practical Paper	EVSUT 234	Practicals related to compulsory theory papers	3
	Choice Based Optional Paper	EVSUT 235	Environmental Management: EMS, Life Cycle Assessment,	2
		EVSUT 236	Environmental resource monitoring	
	Choice based Practical paper	EVSUT 237	Practicals related to elective paper	1
	Core Compulsory	EVSUT 238	Inplant training/ internships	2
IV	Core Compulsory Theory Paper	EVSUT 241	Solid & Hazardous Waste Management	4
		EVSUT 242	Renewable and non-renewable energy	4
	Core Compulsory Practical Paper	EVSUT 243	Practicals related to 141, 142	2
	Choice Based Optional Paper 1	EVSUT 244	Environmental Toxicology, Health & Safety	2
		EVSUT 245	Environmental Economics	
	Choice based Practical paper 1	EVSUT 246	Practical Paper based on Choice based paper 2	1
	Choice Based Optional Paper 2	EVSUT 247	Environmental Biotechnology & Nanotechnology	2
		EVSUT 248	Environmental policy, climate change and sustainability	
	Choice based Practical paper 2	EVSUT 249	Practical Paper based on Choice based paper 2	1
	Core Compulsory	EVSUT 250	Dissertation- final assessment	4
			TOTAL	**40**

SEMESTER III

EVSUT 231	ENVIRONMENTAL IMPACT ASSESSMENT & ENVIRONMENTAL 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 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 produces 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	4
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** a. Ambient Air Quality b. Water including ground and surface c. Soil Conservation d. Noise and Vibrations e. Hydrology, f. Geology g. Ecology and Bio-diversity h. Socio-Economic environment i. Traffic and other data	8
5.	**Impact Analysis/Assessment, Mitigation and Management** i. Impact Identification ii. Impact Analysis/Prediction: methodology ii. Characteristics of Environmental Impacts - Activity – Impact Characterisation v. Social Impact Assessment (SIA): introduction and methodology v. Evaluation of Impact Significance vi. Significance Criteria i. 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 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	12

6	**Detailed Procedure for conducts of 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), 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-	12
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	

EVSUT 232	REMOTE SENSING & GIS (4 CREDITS)	LECTURES 60
UNIT 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** -optical, infrared, microwave, hyperspectral, LIDAR	2
4.	**RESOLUTION OF RS DATA** -spectral, spatial, radiometric, temporal -Spectral signatures -Spectral reflectance curve for vegetation, soil, water	4
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:** TYPES-geosynchronous, sun synchronous polar orbit	2
8.	**REMOTE SENSING ORBITS:** -SCANNING SYSTEMS-multi spectral scanning, push broom, whisk broom, overlap.	3
9.	**TYPES OF SENSORS**- LISS III, LISS IV, Awifs, PAN, CARTOSAT, LANDSAT, RADAR, SRTM, IKONOS	2
UNIT II	**GIS**	
1.	**HISTORY OF GIS**	1
2	**COMPONENTS OF GIS**	1

3	**TYPES OF DATA IN GIS:** Spatial, non-spatial Vector, raster Vector-point, line, polygon Types of non-spatial data: Hierarchical, network, relational, object oriented	4
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
UNIT III	**APPLICATIONS**	
1.	**SATELLITE IMAGE PROCESSING AND INTERPRETATION**: -Factors governing Interpretability, -Elements of image interpretation. -Image correction, rectification techniques.	4
2.	**GPS** -concept and application **-** Indian navigation system IRNSS/Navic	1
3.	**DEM MODELS** **-**DEM, DTM, DSM -applications of these models	1
4.	**Applications of RS and GIS in Environmental Sciences** **-**Land use land cover -natural hazards & disasters -hydrology -soil, water, air monitoring -geological applications	8

	-climate change -agriculture -wildlife, etc. -Case studies of analysis using RS GIS	
5.	**Latest technological advancement and trends in RS GIS** **-**wearable GIS -tracking -drone mapping and environmental survey, etc.	1

EVSUT 233	**RESTORATION ECOLOGY AND WATERSHED MANAGEMENT (4 CREDITS)**	**LECTURES 60**
1	**Restoration Ecology** Eco Restoration: definition, principles, significances, guidelines, etc.	4
2	**Applications of eco-restorations (6 lectures)** **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 supporting ecosystems	6
3	**Eco-restoration and industrial environment (2 lectures)** Eco-restoration of mines (open cast), restoration of solid waste dumping sites, Improving aesthetics by partial restoration at industrial sites	3
4	**Steps involved in Restoration (4 lectures)** Identifying problem, assessment of project sites and parameters, identifying threats, methods available for restoration, selection of restoration methods, monitoring techniques for effective restoration	4
5	**Restoration of other natural habitats/eco-systems (2 lectures)** Mangroves, grasslands, wetlands, restoration of streams, degraded forest patches, coastal ecosystems, etc.	2
6	**Watershed Development** **Concept of watershed management (8 lectures)**	10

	Definition, principle, objectives, Water shed morphology and characterization (with respect to size, elevation & slope, aspects & orientation, watershed shape, drainage network),	
7	**Watershed functions and surveys (8 lectures)** 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	8
8	**Water balance studies and harvesting methods (8 lectures)** Water balance and hydrologic equation, inflow to the watershed, outflow from the watershed. Water harvesting methods: traditional water harvesting structures such as *nadis, Khadin, Rapats*, Lakes, etc. contour bunding, graded bunds /field bunds, land leveling 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	8
9	**Watershed Interventions (8 lectures)** 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.	8
10	**Watershed management (6 lectures)** 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	6

EVSUT 234	**PRACTICALS RELATED TO COMPULSARY THEORY PAPERS (3 CREDITS)**	**LECTURES (45)**

1	**EIA & ENV AUDIT** i. Baseline data collection for one season of any project ii. Case study of any one project	15
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 familiarisation with QGIS free software 6. Browsing and downloading data: From LANDSAT, BHUVAN 7. Toposheet Geo referencing 8. Toposheet Digitization & Preparation of map and map layout 9. Satellite image registration 11. Satellite image enhancement and correction tools 12. Image classification: Supervised and unsupervised 13. Satellite image interpretation	15
3	**RESTORATION ECOLOGY & WATERSHED MANAGEMENT** 1. Mapping of watershed (marking of ridge areas and drainage lines), estimating area and slope. 2. Watershed Planning exercises at milli-watershed level, location specific with identifying specific Watershed interventions required. 3. Rapid site assessment and data interpretation of any degraded ecosystem (field visit) 4. Study of Restored Sites through Visit and Scientific Report writing based on visit(field visit)	15

EVSUT 235	**ENVIRONMENTAL MANAGEMENT: EMS & LCA (2 CREDITS)**	**LECTURES 30**
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	4
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	4

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	
EVSUT 237	**Practicals based on ENVIRONMENTAL MANAGEMENT: EMS & LCA (1 CREDIT)**	**LECTURES 15**
1.	1. Case studies for LCA: 3 different sectors 2. Case studies for environmental design of products 3. Case studies for environmental design of buildings 4. Case study of implementation of EMS in industry	

EVSUT 236	**ENVIRONMENTAL RESOURCE MONITORING (2 CREDITS)**	**LECTURES 30**
1.	**Introduction** Introduction to environmental monitoring; Basics of resources to be monitored.	2
2.	**Air Quality Parameters (10 lectures)** a. weather monitoring - includes light, rainfall, wind direction, wind velocity, temperature, pressure, humidity, etc. broad significance of each of the parameter, monitoring tools/instruments and its work principle, data reporting/presentation method(s), etc. b. ambient air – national standards for ambient air quality, site and parameter selection, monitoring of important ambient air components such as particulate matter (PM) of 10 micron or less in	8

	size and 2.5 micron and less in size, oxides of sulfur and nitrogen, etc limits/standards for these parameters under OSHA, ambient air and work zone monitoring techniques; monitoring tools/instruments used for the same and its work principle, stack gases monitoring technique; limits for different industries for stack gases, stack height determination, criteria for sampling port (Indian Standard (IS) and/or international standards linked with these elements need to be familiarized to student) c. Noise & vibration monitoring: Introduction of noise & vibration; measuring techniques, national standard for noise, noise monitoring methods, d. Noise Impact Criteria: investigation and assessment of impact of noise; Considerations in Applying the Noise Impact Criteria; Mitigation Policy Consideration; Determining the Need for Noise Mitigation e. Odour monitoring: basics, technique/methodology	
3.	**Methods for monitoring/sampling of water and its analysis (10 lectures)** Monitoring of Water, purpose/objectives of monitoring, selection of method suitable to fulfill monitoring objective; Water Quality Monitoring Protocol, frequency and parameters for ground water & surface water, collection of sample (types of sample, chain of custody, sampling method, number of samples, sample containers, sample volume, etc), sample preservation, handling & storage guidelines/criteria, water quality monitoring on field test parameters, off-field test parameters, water quality criteria for different designated best uses; general effluent standards, drinking water standard (IS 10500 and WHO standards); Safety practices Monitoring of pollution of water bodies (rivers, streams, creaks, seas, oceans, etc), monitoring methods, tools/instruments, impact prediction and analysis	5
4	**Monitoring of Soil** Objectives of soil monitoring/testing, sampling and sample units; sample number, frequency and timing; Sampling methodology; a. Site selection b) Infield sampling technique c) Describing the soil profile d) Site description e) Setting a transect instruments / Equipments used, Quality Parameters (testing contaminants/polluting elements), important soil quality indicators - soil acidity (pH); EC; carbon (C);	5

	total nitrogen (N) and carbon to nitrogen ratio; extractable phosphorous (P); extractable potassium (K) and magnesium (Mg); micro nutrients and potentially toxic elements; useful soil microbes. Basic concepts in analysis, Guidelines for handling and storage of samples; Safety practices	
5	**Forest resource monitoring (10 lectures)** Definition and scope. Measurement of individual trees: a) Measurement of diameter and girth of trees b) Measurement of heights of trees c) Measurement of form of trees d) Measurement of volume of felled trees e) Measurement of volume of standing trees f) determination of age of trees g)) determination of increment of trees, increment percent, Sample plot, forest inventory, kinds of sampling, sampling units, sampling intensity. Wild life monitoring: scope, methods/ techniques a) census for invertebrates, fish, amphibian, reptiles, birds and mammals	5
	Reference · Guidelines for the Measurement of Ambient Air Pollutants - Volume-I - Guidelines for Manual Sampling & Analyses by CENTRAL POLLUTION CONTROL BOARD (Ministry of Environment & Forests, Govt. of India), Delhi - May, 2011 · GUIDE MANUAL: WATER AND WASTEWATER ANALYSIS by CENTRAL POLLUTION CONTROL BOARD (Ministry of Environment & Forests, Govt. of India), Delhi - May, 2011 · Guidelines for Water Quality Monitoring by CENTRAL POLLUTION CONTROL BOARD (Ministry of Environment & Forests, Govt. of India), Delhi - MINARS/27/2007-08 · Guidelines for Water Quality Management - by CENTRAL POLLUTION CONTROL BOARD (Ministry of Environment & Forests, Govt. of India), Delhi · Horizontal Guidance Note IPPC H3 (part 2) - Noise Assessment and Control - Version 3 June 2004 Environment Agency Rio House, Waterside Drive, Aztec West, Almondsbury, Bristol BS32 4UD · Handbook of Forestry by Khanna LS and Chaturvedi AN; Publiched by Khanna Bandhu, Dehradun ISBN 81-85933-24-3 · Land and Soil Monitoring: A guide for SoE and Regional Council Reporting; New Zealand Published by the Land Monitoring Forum, New Zealand. 2009	
EVSUT 237	**Practicals based on ENVIRONMENTAL RESOURCE MONITORING (1 CREDIT)**	**LECTURES 15**
1.	1. TO BE INCLUDED	

EVSUT 238	**SUMMER INTERNSHIPS / IN-PLANT TRAINING (2 CREDITS)** Students are expected to spend a minimum of 45 days during their semester break under the guidance of a competent professional / scientist at a research institute or research centre with the aim of learning techniques and their applications. The assessments should be based on supervisor's feedback, submission of a training report and a open presentation and Viva voce.	**LECTURES 30**

SEMESTER IV

EVSUT 241	**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 of it. Characterization: physical & chemical characteristics, 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 existing situation & possible areas for improvement	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	10
5.	**Biomedical waste management:** Define, scope, categorization, segregation, packaging/colour coding and container used, treatment, transport and disposal, status in India.	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 various authorities.	14
7.	**Radioactive waste management**	4
8.	**Electronic waste management:** A growing problem, sources, segregation, collection, recovery of valuable materials, treatment	4

	and disposal methods	
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	4
10.	**Construction and demolition waste management**	2
	Recommended Reference Material: 1. M.S. Bhatt and AsherefIlliyan. 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, NareshDavergave. 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.	

EVSUT 242	**RENEWABLE & NON RENEWABLE ENERGY (4 CREDITS)**	**LECTURES 60**
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 transformtion. Impact of Energy Systems on environment.	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 associated with exploration / mining, processing, transportation and uses	10
3.	**Bio-energy** Biomass composition and types; Conversion processes – pyrolysis, charcoal production, compression, gasification and liquefaction;	8

	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.	
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, Renewable Energy Integration and Decentralized Generation Systems. 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, Energy in Buildings, Energy Planning and Economics and Energy Field Visits/Industrial Training.	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 energynsysttems on environment.	6
7.	**Hydroelectricity** Principles of generation of hydroelectric power, hazard related to hydropower generation and distribution, environmental impact	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	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; Ashis Publishing House 7. Geography and Energy – Commercial energy systems and national policies: J.D. Chapman	

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EVSUT 243	**Practicals based on Compulsory Theory Papers (2 CREDITS)**	**LECTURES 30**
1.	**Solid and hazardous waste management**	15
2.	**Renewable and non renewable energy** 1. Estimation of calorific value of given wood sample /solid waste 2. Visit to landfill site/waste processing site 3. Estimation of monthly average of daily solar radiations incident on earth surface of University campus (Sunshine Recorder) 4. Study of carbonization processes (Charcoal making) by technique of wood pyrolysis 5. Analysis of wind power available for installation of wind mill 6. Estimation of out heat of combustion of given fuel sample 7. Study of waste segregation and recycling	15

EVSUT 244	**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. • Environmental & Safety policy and its implementation	7

	• Safety as a tool for maximizing production and sustainable development.	
2.	**Health and Safety Risk Management (8 lectures)** • 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.	8
3	**Toxicology (2 lectures)** • Fundamental of toxicology, Basic concepts, toxicity and its impacts. • Nature of toxic effects, Acute and Chronic. • Industrial toxicants and hazardous materials. **Measurement of toxicity (4 lectures)** • Measurement of toxicity- LD50, LC50, Nature of dosage-response relationship. • Use of dosage-response information, Factors influencing toxicity. • Lethality studies, physiological and metabolic effects on flora and fauna. **Evaluation of toxicity (6 lectures)** • 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.	12
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

EVSUT 246	**Practicals related to ENVIRONMENTAL TOXICOLOGY HEALTH & SAFETY (1 CREDIT)** **<u>Any 7 of following:</u>** 1. Study on effect of heavy metal toxicants on the germination of Ground nut. 2. Determination of LC 50 of any toxicant. 3. Estimation of any toxicant by agar diffusion assay. 4. Effect of Heavy Metal toxicants on the behavior pattern of Earthworm. 5. Basic Toxicity Assays: Ames Assay 6. Basic Toxicity Assays: MTT assay 7. Comet Assay 8. Industrial visit for occupation health and safety management. 9. Hazard and risk analysis - a industrial case study 10. First Aid Practices 11. Safety Practices in scientific Laboratories. 12. Demonstration of Fire Protection (fire extinguishers, Fire hydrant system, sprinkler 13. system, fire alarm)	**15**

EVSUT 245	**ENVIRONMENTAL ECONOMICS (2 CREDITS)**	**LECTURES 30**
1.	**Environmental Economics** • Origin of basic economics, definitions, scope and importance. • Importance of Environmental economics aspects in ancient, medieval and modern age. • The Economy and the Environment: Two Parts of a Whole – Interlinkages between the economy and the environment.	8
2	**Micro Foundations of Environmental Economics** • Micro Foundations of Environmental Economics - Theory of Public goods, Externalities and Market failure. • The Problem of Social Cost - Design of Environmental Policy. • Global and Indian perspective of environmental economics.	7
3	**Economic Instruments for Environmental Protection** GDP, NNP, GHI, Green GDP, HDI, Green Economy. • Command & Control versus Incentives and Subsidies - Available Policy Options • Effectiveness of these instruments, International Comparisons.	8

4	**Economics of Natural Resource Exploitation** Renewable and Non-Renewable Resources – Methods of valuation of Environmental Costs and Benefits. • Economic Growth and the Environment. • Foreign Direct Investment Inflow and the Environmental quality.	7
	Texts/References: • Hanley, Nick, Jason F. Shogren & Ben White: ***Environmental Economics in Theory and Practice***, New Delhi: Macmillan – India, 1997. • James, D.E., ***Economic Approaches to Environmental Problems: Techniques and Results of Empirical Analysis***, Elsevier Scientific Publishing Co., 1978. • Nash, R.F., ***The Rights of Nature: A History of Environmental Ethics***, University of Wisconsin, 1989. • Whytte, Anne, V. and Ian Burton (eds), ***Environmental Risk Assessment***, John Wiley & Sons, 1980. • Allen V. Kneese and James L. Sweeney, eds. ***Handbook of Natural Resource and Energy Economics***, Chapters 2,12,14,17, North Holland, 1985. • Fisher, A.C., Environment and Resource Economics, Selected readings***, New Horizon in Environmental Economics***, Ed. W.E. Oates, 1995. • Bohm, P. and Russell, C., `Comparative Analysis of Alternative Policy Instruments', Chap. 10 in ***Handbook of Natural Resource and Energy Economics***, Vol.I Ed. A.V. Kneese and J.L. Sweeney, 1985.	
EVSUT 246	**Practicals related to ENVIRONMENTAL ECONOMICS (1 CREDIT)** **TO BE ADDED**	**15**

EVSUT 247	**ENVIRONMENTAL BIOTECHNOLOGY & NANOTECHNOLOGY (2 CREDITS)**	**LECTURES 30**
1.	**Environmental Biotechnology: Concepts and Scope:** • The scope of environmental biotechnology; Concept and various applications. Biosafety, Recombinant DNA guidelines	2

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
3	**Environmental Applications of Biotechnology:** • Biosensors, Bio-monitors for detecting environmental pollutants • **Bioremediation:** Concept; Natural and Engineered; in situ, ex situ, biostimulation, 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, Biomethanation.	5
4.	**Environmental Nanotechnology:** • Overview - Definition, Historical perspectives, Scope, Environmental applications	2
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
6	**Synthesis and Characterization of Nanoparticles:** • Basics of nanoparticle synthesis techniques (Chemical, Physical and Biological synthesis); Functionalization of	5

	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)	
7	**Environmental Nanoremediation**: • Definition, current applications of nanotechnology for environmental cleanup such as use of non-zerovalent iron (nZVI), bimetallic nanoparticles, titanium dioxide nanomembranes, 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.	5
EVSUT 249	**Practicals based on environmental biotechnology & nanotechnology (1 CREDITS)** 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 3 P Physical Chemical and Biological methods 7. Characterization of synthesized nanoparticles	**15**

EVSUT 248	**CLIMATE CHANGE, POLICY & SUSTAINABILITY (2 CREDITS)**	**LECTURES**
Unit I	**UNDERSTANDING CLIMATE DYNAMICS** • **Earth's Palaeoclimatic 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 & Industrilization • **Proxies of climate change:** Tree rings, microfossils, oxygen-carbon	**10 Lectures**

	isotopes, speleothems, spores and pollen, trace elements, corals, geochemical proxies • **Climate Elements and Effects:** Green House Gases, Sources and Sinks of GHGs, Role and impact of GHGs, Atmospheric Life of GHGs, Global Warming Vs. Global Dimming, Pre- and Postindustrial emissions	
Unit II	**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** • **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	**10 Lectures**
Unit III	**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	**10 Lectures**
	Reference Books: 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)	
EVSUT 249	**Practicals based on CLIMATE CHANGE, POLICY & SUSTAINABILITY (1 CREDIT)**	**15**
	1. Visit to IITM Centre for Climate Change 2. Analysis of historical instrumental data from IMD 3. Extraction of climatic data from repositories like Earth Null	

	School, NOAA, IMD, etc 4. Introduction to General Circulation Models 5. Demonstration of proxies: Microfossils, Speleothems, Sediment, etc. 6. Survey based studies of change in socio-economic shifts 7. RS-GIS based Land Use-Land Pattern Change 8. Numericals related to carbon sequestration, carbon and water footprints and trading	

EVSUT 250	**SUMMER INTERNSHIPS / IN-PLANT TRAINING (4 CREDITS)** Students are expected to spend a minimum of 120 days working on a Master's thesis based on research, development of technique, data collection and/or analysis, and work towards a problem that involves goal setting, previous literature survey, systematic laboratory work, reporting results and discussing it in context to existing knowledge. The assessments should be based on supervisor's feedback, continuous progress assessments by departmental faculty, submission of a master's dissertation thesis and a open presentation and Viva voce.	**LECTURES 60**