ACADEMIC REGULATIONS,

PROGRAM STRUCTURE AND SYLLABUS

For

M.Sc. (ENVIRONMENTAL SCIENCE & TECHNOLOGY)

(Full Time PG Program)

ACADEMIC YEAR 2022-2023

CENTRE FOR ENVIRONMENT
UNIVERSITY COLLEGE OF ENGINEERING, SCIENCE & TECHNOLOGY HYDERABAD
(Autonomous)
JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
KUKATPALLY, HYDERABAD-500 085,
TELANGANA STATE, INDIA.

CENTRE FOR ENVIRONMENT
UNIVERSITY COLLEGE OF ENGINEERING, SCIENCE & TECHNOLOGY HYDERABAD
JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
KUKATPALLY, HYDERABAD-500 085,
TELANGANA STATE, INDIA.

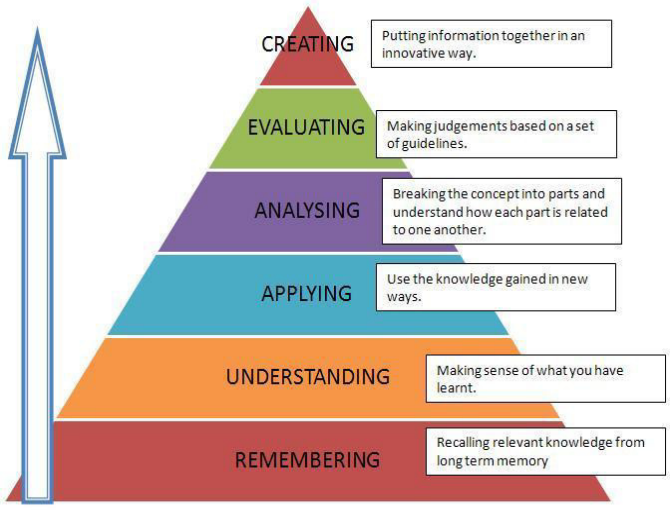
Vision:

- To disseminate advance knowledge by providing effective instruction and innovative research in environmental science and technology by promoting inter-disciplinary studies and research.
- To respond and to find technological solutions for pollution monitoring, abatement and control through innovation in environmental chemistry, environmental biotechnology and Environmental Geomatics.
- To maintain and develop liaison/collaboration with reputed universities, R&D organizations, industries and consultancy firms in India and abroad.

Mission:

- Producing highly motivated, technically competent, morally strong graduates with deep roots in our culture and with ability to respond to global challenges, thereby delighting all stakeholders namely parents, employers and humanity at large.
- To excel as a Center of Higher Education and Research in the field of Environmental Science & Technology.

Blooms Taxonomy:



ACADEMIC YEAR 2022-2023
CENTRE FOR ENVIRONMENT
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M.Sc.-ENVIRONMENTAL SCIENCE & TECHNOLOGY
COURSE STRUCTURE

I Year - I SEMESTER

Subject Code	I semester	Course Title	Int. Marks	Ext. Marks	L	P	C
1ESTPC01	Program Core I	Ecology and Natural Resources	40	60	3	-	3
1ESTPC02	Program Core II	Environmental Chemistry	40	60	3	-	3
1ESTPC03	Program Core III	Environmental Microbiology	40	60	3	-	3
1ESTPE04	Program Elective I	1) Solid & Hazardous waste management 2) Geostatistics 3) Disaster Management	40	60	3	-	3
1ESTOE05	Open Elective I	1) Intellectual Property Rights & Research Methodology 2) Drinking water Treatment & Supply 3) Plastic Waste Management	40	60	3	-	3
1ESTL06	Laboratory I	Environmental Monitoring Lab	40	60	-	6	3
1ESTL07	Laboratory II	Environmental Microbiology Lab	40	60	-	6	3
1EST08		Seminar	-	50	3	-	2
	TOTAL		**280**	**470**	**18**	**12**	**23**

I Year - II SEMESTER

Subject Code	II semester	Course Title	Int. Marks	Ext. Marks	L	P	C
2ESTPC09	Program Core IV	Air Pollution Control Technologies	40	60	3	-	3
2ESTPC10	Program Core V	Environmental Biotechnology	40	60	3	-	3
2ESTPC11	Program Core VI	Environmental Geomatics	40	60	3	-	3
2ESTPE12	Program Elective II	1) Instrumental methods of Analysis 2) Bioremediation Technologies 3) Environmental Law & Audit	40	60	3	-	3
2ESTOE13	Open Elective II	1) Global Environmental issues 2) Biomass Conversion And Technologies 3) Urban Land use Planning & Smart cities	40	60	3	-	3
2ESTL14	Laboratory III	Environmental Geomatics Lab	40	60	-	6	3
2ESTL15	Laboratory IV	Environmental Biotechnology Lab	40	60	-	6	3
2EST16		Seminar	-	50	3	-	2
	TOTAL		**280**	**470**	**18**	**12**	**23**

II Year - III SEMESTER

Subject Code	III semester	Course Title	Int. Marks	Ext. Marks	L	P	C
3ESTPC17	Program Core VII	Environmental Impact Assessment	40	60	3	-	3
3ESTPC18	Program Core VIII	Waste water Treatment Technologies	40	60	3	-	3
3ESTPC19	Program Core IX	Environmental Modeling	40	60	3	-	3
3ESTPE20	Program Elective III	1) Environment, Health & Safety 2) Climate Change & Sustainable Development 3) Applied Geomatics	40	60	3	-	3
3ESTOE21	Open Elective III	1) Waste to Energy 3) Energy Audit 3) Green Built Environment 4) Prokaryotic Diversity and Bio-Prospecting(Tiny Earth course of USA)	40	60	3	-	3
3ESTL22	Laboratory V	Wastewater Treatment Lab	40	60	-	6	3
3ESTL23	Laboratory VI	Environmental Modeling Lab	40	60	-	6	3
3EST24		Seminar	-	50	3	-	2
	TOTAL		**280**	**470**	**18**	**12**	**23**

II Year - IV SEMESTER

Subject code	IV Semester	Int. Marks	Ext. Marks	L	P	C
	Dissertation / Project work Review I	00	00	0	0	0
4EST25	Project Work Review II	50	-	-	4	2
4EST26	Project Evaluation (Viva Voce)	-	100	-	18	9
	Total	**50**	**100**	-	**22**	**11**

Total Marks: 750+750+750+150 = **2400**
Total Credits: 23+ 23+23+11 = **80**

Course Title	**ECOLOGY AND NATURAL RESOURCES**		
Course code	**1ESTPC01**	No. of credits	3
Center/ Department	Center for Environment , IST, JNTUH		
Program	M.Sc. (Environmental Science & Technology)		
Course type	**Program Core I**		
Course outcomes (COs)	**At the end of the course, the Student will be able to** **CO1:**Describe fundamental processes that shape ecosystem structure and function in forests, range lands and aquatic systems **CO2:** Analyze and anticipate ecosystem response to disturbance and management activities **CO3:**Identify science-based management practices to address common ecological challenges **CO4:** Manipulate and interpret ecological data from natural resource systems. **CO5**: Analyse the renewable and nonrenewable resources and demand		

UNIT I CONCEPT OF ECOSYSTEM:

Definition, Concept of a system; Biotic, a biotic and ecological systems. Structure, functions and classification of ecosystems. Ecological pyramids.
Ecological: Flow of energy through food chains and food webs; Laws of thermodynamics; entropy, ecological efficiency; food chain concentration. Biogeochemical cycles or Nutrient Cycles: General considerations of recycling; Gaseous and sedimentary cycles; rates of turnover and turnover time. Causes and consequences of disruption of nutrient cycles with reference to Greenhouse gases and SO_x. Hydrological cycle.

UNIT II POPULATION ECOLOGY:

Concept of a species and definition of a population. Biological and group attributes of populations. Density, natality, mortality, migrations and growth of populations. Natural regulation of populations. Human population explosion and its consequences.

UNIT III NATURAL RESOURCES:

Classification of natural resources, biotic resources; Renewable and non-renewable resources: Different types of resources and their natural sources. Demographic quotient; rate of consumption and depletion. Value system, equitable resource use. Soil formation and soil erosion; Changes in land use and land cover pattern; conservation of soil and nutrients. Water resources: Distribution, exploitation, depletion of water resources; conservation of water; water use efficiency; water poverty index.

UNIT IV MINERAL AND LAND RESOURCES:

Distribution and exploitation; environmental implications of mining; strategies for conservation of mineral resources, land evaluation and suitability, land use/land cover mapping, LU/LC for Environmental Planning.

UNIT V ENERGY RESOURCES:
Renewable and non-renewable resources energy; Alternate and additional sources of energy; depletion of energy resources; Conservation of energy resource; Energy use efficiency. Solar radiation and its technological ways of harvesting; Solar collectors, photovoltaic, solar ponds; Hydroelectric power, Tidal, Ocean Thermal Energy Conversion, Wind, Geothermal Energy, Nuclear energy-fission and fusion, Hydrogen & Fuel cells.
Books Recommended 1. Dr.M.Anji Reddy Environmental Sciences, BS Publications 2. Fundamentals of Ecology by E Podum, WB Saurders & Co. 3. Environment and Natural Resources conservation by Trivedi R.K. 4. Remote sensing in Geology to Siegal, John Wiley 1999

Course Title	**ENVIRONMENTAL CHEMISTRY**		
Course code	**1ESTPC02**	No. of credits	03
Center/ Department	Center for Environment , IST, JNTUH		
Program	M.Sc. : Environmental Science & Technology		
Course type	**Program Core II**		
Course outcomes (COs)	**At the end of the course, the Student will be able to** **CO1:** understand the essential theoretical background of the principles of chemistry applied to the solutions of environmental problems **CO2:**describe the reactions that occurs in polluted and non-polluted atmosphere **CO3:** explain the significance of water, water quality, redox reaction that occurs in water and effects of water pollutants. **CO4**: describe the difference between polluted soil and non-polluted soils, causes for soil deterioration and chemical reaction that occur in soil **CO5:**explain the principle, parts and operation of the instruments used for analyzing the pollution parameters in environmental samples		
UNIT I: FUNDAMENTALS OF ENVIRONMENTAL CHEMISTRY			
Stoichiometry, chemical equilibria and kinetics, acid base reactions, solubility product, solubility of gases in water, the carbonate system, unsaturated and saturated hydrocarbons, radionuclides green chemistry.			
UNIT II: ATMOSPHERIC CHEMISTRY			
Structure and composition of atmosphere - Chemical reactions in the atmosphere: Ozone chemistry- CFC's – Acid Rain – Photochemical smog - Aerosols types- production and distribution- Aerosols and Radiation–- Green House gases			
UNIT III: WATER CHEMISTRY			
physical and chemical properties of water, complexation in natural and waste water - Water pollutants- Types – Sources- Heavy metals – Metalloids – Organic – Inorganic – Biological and Radioactive – redox reactions in various water bodies including marine environment– Groundwater – Potable water -Aquatic Stratification and chemical species distribution			
UNIT IV: SOIL CHEMISTRY			
Physical and Chemical Properties – Cation exchange capacity – soil pH –Leaching and erosion – reactions with acids and bases – Geochemical reactions that neutralize acidity – Biological Process that neutralize acidity – salt affected soils – Trace metals in soils.			

UNIT V: ENVIRONMENTAL ANALYTICAL CHEMISTRY
Chemical methods of analysis gravimetry, titrimetric, Instrumental methods and analysis: Spectroscopy (UV-Visible, AAS, Flame photometer) Chromatography: (GC, GC-MS, HPLC & LCMS), TOC analyser, TN analyser, Radioactive: Gama spectrometer, alpha, beta Counters.
Books Recommended 1. Environmental Chemistry, A Global Perspective by Gary W. Vanloon & Stephen J. Duffy - Oxford University press. 2. Chemistry for environmental Engineering and science fifth edition by Clair N. Sawyer Perry L. McCarthy, Gene F. Parkin, Tata McGraw Hill edition. 3.Environmental Chemistry by A.K. de, 4th edition New Age International (p) Ltd. New Delhi, India, 2000. 4. Fundamentals of Environmental chemistry, 2nd ed. CRC press, Inc., USA, 2001. 5. Water chemistry - Vernon L. Snoeyink, David Jenkins

Course Title	**ENVIRONMENTAL MICROBIOLOGY**		
Course code	**1ESTPC03**	No. of credits	3
Center/Department	Center for Environment, IST,J NTUH		
Program	M.Sc. : Environmental Science & Technology		
Course type	**Program Core III**		
Course outcomes (COs)	**At the end of the course, the student will be able to:**		
	CO1: The students will be able to draw the structures of typical Prokaryotic and eukaryotic cell structures and label. They would be able To find out the similarities and differences between the two cell types. They would be able to explain the general characters and their beneficial and harmful effects. **CO2:** The students will be able to list various nutritional requirements of microorganisms and classify the nutrients. They will be able to categorize different nutritional types based on different criteria and classify microorganisms into different nutritional types. From media composition students will be able to predict nutritional types of organisms. **CO3:** The students will be able to list, describe, differentiate and suggest suitable methods of isolation, preservation of microorganisms. Students will be able to explain different methods for determining growth and differentiate and analyze relative advantages and disadvantages. Students will be able to draw bacterial growth curve and label them. They will be able to explain the changes that take place during various stages.		
	CO4: Students will be able to categorize microorganisms based on the Range of environmental parameters in which they grow. Students will be able to explain different effects of extremes of environment and microbial adaptations to grow under extremes. Students will be able to list out, define and explain different types of microbial control. They will also be able to list various physical and chemical control agents, their mode of action applications, advantages and limitations. They will be able to compare and contrast between different processes and agents of microbial control. Students will be able to suggest a suitable antimicrobial agent for a particular situation and substantiate.		
	CO5: Students will be able to explain various biochemical reactions involved in microbial metabolism. They will be able to draw various biochemical cycles involved metabolism of microorganisms. They will be able to differentiate the anoxygenic and oxygenic photosyntheisis process.		

UNIT I: DIVERSITY OF MICROORGANISMS
Eukaryotic and prokaryotic cell structure, Prokaryotes and eukaryotes General characters, beneficial and harmful effects of major groups of microorganisms, protozoa, algae, fungi, bacteria and viruses
UNIT II: MICROBIAL NUTRITION
Microbial nutrition, Nutritional requirements, major elements, minor elements trace metals and growth factors, Nutrient media (selective, differential, enriched, enrichment and special purpose media) and growth conditions. Nutritional types based on energy source, principal carbon source, electron donor. Proto and auxotrophs, copio and oligotrophs, phago and osmotrophs
UNIT III: MICROBIAL GROWTH
Isolation, cultivation (aerobic & anaerobic) and preservation of microorganisms, methods for determining growth (bacterial numbers, mass and cell constituents), Physiology of growth, bacterial growth curve, Exponential growth and generation time, Bacterial growth in batch and continuous culture (chemostat and turbidostat), synchronous growth
UNIT IV: EFFECT OF ENVIRONMENT & CONTROL MICROORGANISMS
Effect of temperature, pH, O2, radiant energy, osmotic pressure and dessication on microorganisms and microbial adaptations, Control of microorganisms by physical and chemical agents, sterilization disinfection, sanitization and antisepsis, Physical agents – temperature, filtration, and radiation. Classes of disinfectants – phenol and phenolics – alcohol, halogens, surfactants, and heavy metals, Desirable characteristics of an antimicrobial agent; mode of action of antimicrobial agent, Evaluation of antimicrobial agents
UNIT V MICROBIAL METABOLISM AND ENERGY CONVERSION:
Glycolysis, TCA cycle, EDP and HMP pathways, oxidative and photophosphorylation, anaerobic respiration and fermentation, bacterial photosynthesis -oxygenic and anoxygenic, CO2 fixation. Autotrophic CO2 Fixation: Calvin cycle, Reverse Citric Acid cycle.
Books Recommended 1. Environmental Microbiology – Maier, R.M; Pepper, L; Gerba, C.P.-2015- 3rd edition, Academic Press. 2. Microbiology – Pelczar, K.J; Chan, E.C.S; Kreig, N.R.- 2017-5 th edition – Tata McGraw Hill Publishing 3. Microbial Biotechnology – Glazer, A.N; Nikaido, H-2007-2 nd edition Cambridge University Press. 4. Microbiology Prescott, Joanne M Willey, Kathleen Sandman, Dorothy Wood -2020, 11th Edition, McGraw-Hill publishing company. **References Text Books:** 5. Review articles in Advances in Applied Microbiology, critical reviews in microbiology, Annual review of Microbiology, Bacteriology etc.

	SOLID & HAZARDOUS WASTE MANAGEMENT		
Course code	**1ESTPE04**	No. of credits	03
Center/ Department	Center for Environment , IST, JNTUH		
Program	M.Sc. : Environmental Science & Technology		
Course type	**Program Elective I**		
Course outcomes (COs)	**At the end of course, the student will able to** **CO1:** explain about different solid wastes sources, characteristics and their effects on environment. **CO2:** Explain about the MSW management practices and the required level of treatment based on regulatory aspects. **CO3:** Define the hazardous waste and explain the characteristics, treatment and disposal methods according to regulatory aspects. **CO4:** give introduction to the radioactive waste management and can describe the biomedical waste segregation, treatment and disposal according to BMW rules. **CO5:** Define E-waste, explain the characteristics and sources, illustrate the treatment and recovery processes of E-waste.		
UNIT I: SOLID WASTE			
Definition of solid wastes – types of solid wastes – Sources - Industrial, mining, agricultural, municipal solid waste, Construction demolition waste, E-waste and Biomedical waste. Solid waste Problems - impact on environmental health			
UNIT II: FUNCTIONAL ELEMENTS OF SOLID WASTE MANAGEMENT			
Handling and segregation of wastes at source. Collection and storage of municipal solid wastes; analysis of Collection systems. Transfer stations. Solid waste processing technologies: Mechanical and thermal volume reduction, Biological and chemical techniques for energy and other resource recovery, composting, vermicomposting, fermentation. Incineration of solid wastes. Disposal in landfills: site selection, design, and operation of sanitary landfills; Leachate and landfill gas management; landfill closure and post-closure environmental monitoring; landfill remediation. Regulatory aspects of municipal solid waste management.			
UNIT III: HAZARDOUS WASTE AND MANAGEMENT			
Hazardous waste definition. Physical and biological routes of transport of hazardous substances – sources and characterization. Sampling and analysis of hazardous wastes –proximate analysis – survey analysis – directed analysis - handling, collection, storage and transport. Hazardous waste treatment technologies: TSDF concept - Physical, chemical and thermal treatment of hazardous waste: solidification, chemical fixation, encapsulation, pyrolysis and incineration. Hazardous waste landfills - Site selections, design and operation. HW reduction, recycling and reuse fly ash bricks, Regulatory aspects of HWM/HWM rules.			

UNIT IV: BIOMEDICAL AND RADIOACTIVE WASTE MANAGEMENT
Classification, collection, segregation Treatment and disposal. Radioactive waste: Definition, Low level and high level radioactive wastes and their management, Radiation standard by ICRP and AERB
UNIT V: E-WASTE MANAGEMENT
E-Waste: Characteristics, generation, collection, transport and disposal, regulatory aspects of E-waste, Global strategy, recycling. Plastic waste management.
Books Recommended 1. Hazardous waste management Charles A. Wentz. Second edition 1995. McGraw Hill International. 2. Integrated solid waste management George Tchobanoglous, Hilary Theisen & Sammuel A. Vigil. 3. Criteria for hazardous waste landfills – CPCB guidelines 2000. 4. Hazardous waste management by Prof. Anjaneyulu. 5. Environmental Sciences by Daniel B. Botkin and Edward A. Keller, Wiley student, 6th edition- 2009. 6. Standard handbook of Hazardous waste treatment and disposal by Harry M. Freeman, McGraw Hill 1997. 7. Management of Solid waste in developing countries by Frank Flintoff , WHO regional publications 1976 **Online Resources:** 1.https://www.eawag.ch/fileadmin/Plastic_recycling_ISWA_2014.pdf 2.https://marinelitter.iswa.org/PlasticwasteMarine_Task_Force_Report_2017/ISWA_report_interactive.pdf

Course Title	GEOSTATISTICS		
Course code	2ESTPE04	No. of credits	3
Center/ Department	Center for Environment , IST, JNTUH		
Program	M.Sc. : Environmental Science & Technology		
Course type	Program Elective I		
Course outcomes (COs)	**CO1:** Examine the statistics applications and frequency. **CO2:** Establish the measurement and its analysis process in standard deviation etc. **CO3:** Estimate the probability studies and error sources. **CO4:** Examine the correlations and regressions **CO5:** Organize the test significance and statistical process control		

UNIT I: INTRODUCTION AND FREQUENCY DISTRIBUTION:

Overview of Applications of statistics in environmental problem solving; Raw data, Arrays, Class interval and Class limits, Class boundaries, Size, width of a class interval, class mark, general rules for forming frequency distributions; Histograms and frequency polygons, frequency distributions and curves.

UNIT II: MEASUREMENTS AND THEIR ANALYSIS:

Introduction, Sample Versus Population, Range and Median, Graphical Representation of Data, Numerical Methods of Describing Data, Measures of Central Tendency, Standard deviation and other measures of Dispersion.

UNIT III: RANDOM ERROR THEORY AND CONFIDENCE INTERVAL:

Introduction, Theory of Probability, Properties of the Normal Distribution Function, Probability of the Standard Error, Uses of Percent Errors, Moments, Skewness and Kurtosis
Introduction, Distributions used in Sampling Theory, Confidence Interval for the Mean, Sampling, its uses, some sampling distributions, Analysis of Variance (ANOVA).

UNIT IV: CORRELATION AND REGRESSION:

Curve fitting and the method of Least squares, Correlation theory, Multiple and partial correlations, Linear regression, Multiple regression, R^2, regression modeling.

UNIT V: STATISTICAL TESTING AND STATISTICAL ANALYSIS:

Tests of significance, Chi-square and F-test, Non parametric tests, t-tests.

Books Recommended

1. Theory and Problems of STATISTICS by Murray R. Spiegel and Larry J. Stephens
2. Basics Statistics by B.L.Agarwal
3. Introduction to statistical Analysis by Wilfred J. Dixon and Frank J. Massey JR

Course Title	DISASTER MANAGEMENT		
Course code	2ESTPE04	No. of credits	3
Center/ Department	Center for Environment , IST, JNTUH		
Program	M.Sc. : Environmental Science & Technology		
Course type	Program Elective I		
Course outcomes (COs)	**CO1:** learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response. **CO2:** critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives. **CO3:** develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations. **CO4:** critically understand the strengths and weaknesses of disaster management approaches, planning and programming. **CO5:** Estimation of Risk & mitigation measures		

UNIT I: OVERVIEW OF DISASTERS

Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.

UNIT II: REPERCUSSIONS OF DISASTERS AND HAZARDS

Economic Damage, Loss of Human And Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

UNIT III: DISASTER PRONE AREAS IN INDIA

Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases And Epidemics.

UNIT IV: DISASTER PREPAREDNESS AND MANAGEMENT

Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data from Meteorological And Other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT V: RISK ASSESSMENT & DISASTER MITIGATION
Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation in Risk Assessment. Strategies for Survival. Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends in Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs of Disaster Mitigation in India.
Books Recommended 1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company. 2. Sahni, PardeepEt.Al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi. 3. Goel S. L., Disaster Administration And Management Text And Case Studies",Deep &Deep Publication Pvt. Ltd., New Delhi.

Course Title	INTELLECTUAL PROPERTY RIGHTS & RESEARCH METHODOLOGY		
Course code	1ESTOE05	No. of credits	3
Center/ Department	Center for Environment , IST, JNTUH		
Program	M.Sc. : Environmental Science & Technology		
Course type	Open Elective I		
Course outcomes (COs)	**At the end of the course, the student will be able to** **CO1:** Understand research problem formulation. **CO2:** Analyze research related information, Follow research ethics **CO3:** Understand that today's world is controlled by computers and Information Technology, but tomorrow the world will be ruled by ideas, concepts, and creativity. **CO4**: Understanding that when IPR would take such an important place in the growth of individuals & nation, it is needless to emphasize the need for information about Intellectual Property Right to be promoted among students in general & engineering in particular. **CO5:** Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about economic growth and social benefits.		

UNIT I :

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.
Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

UNIT II :

Effective literature studies approach, analysis Plagiarism, Research ethics,
Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

UNIT III:

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT IV:

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

UNIT V:

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Books Recommended

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
3. Ranjit Kumar, 2 nd Edition, "Research Methodology: A Step by Step Guide for beginners"
4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd,2007.
5. Mayall , "Industrial Design", McGraw Hill,1992.
6. Niebel , "Product Design", McGraw Hill,1974.
7. Asimov, "Introduction to Design", Prentice Hall,1962.
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age",2016.
9. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand,2008

Course Title	**DRINKING WATER TREATMENT & SUPPLY**		
Course code	**1ESTOE05**	No. of credits	03
Center/ Department	Center for Environment , IST, JNTUH		
Program	M.Sc. : Environmental Science & Technology		
Course type	**Open Elective - I**		
Program outcomes (POs)	**At the end of the course, the Student will be able to** **CO1:** Explain design concepts related to water transmission mains, water distribution system, sewer networks and storm water drain and computer application on design. **CO2:** Select various pipe materials for water supply main, distribution network and sewer **CO3 :** Design water supply main, distribution network and sewer for various field conditions. Troubleshooting in water and sewage transmission. **CO4:** Apply various computer software for the design of water and sewage networks.		
UNIT I: GENERAL HYDRAULICS AND FLOW MEASUREMENT			
Fluid properties; fluid flow – continuity principle, energy principle and momentum principle; frictional head loss in free and pressure flow, minor heads losses, Carrying Capacity–Flow measurement.			
UNIT II: WATER TRANSMISSION AND DISTRIBUTION			
Need for Transport of water and wastewater-Planning of Water System –Selection of pipe materials, Water transmission main design- gravity and pumping main; Selection of Pumps-characteristics- economics; Specials, Jointing, laying and maintenance, water hammer analysis; water distribution pipe networks Design, analysis and optimization – appurtenances – corrosion prevention – minimization of water losses – leak detection Storage reservoirs.			
UNIT III: WASTEWATER COLLECTION AND CONVEYANCE			
Planning factors – Design of sanitary sewer; partial flow in sewers, economics of sewer design; Wastewater pumps and pumping stations- sewer appurtenances; material, construction, inspection and maintenance of sewers; Design of sewer outfalls-mixing conditions; conveyance of corrosive wastewaters.			
UNIT IV: STORM WATER DRAINAGE			
Necessity- - combined and separate system; Estimation of storm water run-off Formulation of rainfall intensity duration and frequency relationships- Rational methods			
UNIT V: CASE STUDIES AND SOFTWARE APPLICATIONS			
Use of computer software in water transmission, water distribution and sewer design – EPANET 2.0, LOOP version 4.0, SEWER, BRANCH, Canal ++ and GIS based software.			

Books Recommended

1. Bajwa, G.S. "Practical Handbook on Public Health Engineering", Deep Publishers, Shimla, 2003
2. “Manual on water supply and Treatment”, CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 1999.
3. “Manual on Sewerage and Sewage Treatment”, CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 1993.

Course Title	**PLASTIC WASTE MANAGEMENT**		
Course code	**1ESTOE05**	No. of credits	03
Center/ Department	Center for Environment , IST, JNTUH		
Program	**M.Sc. Environmental Science and Technology**		
Course type	**Open Elective-I**		
Course outcomes (COs)	**At the end of the course, the Student will be able to** **CO1:** Identify types of plastics, their applications, and plastic waste sources. **CO2:** Explain national and global plastic waste management rules. **CO3:** Assess health and environmental impacts of plastic waste. **CO4:** Specify plastic waste management practices. **CO5:** Identify alternative materials to plastic and their benefits in terms of circular economy.		
UNIT – I: Plastic waste Introduction.			
Plastic definition. Types of plastic. Plastics production and manufacturing process. Characteristics of Plastics. Classification of plastics. Plastic applications and uses.			
UNIT – II: Rules & Regulations			
Global statistics of plastics. Plastic waste sources. Global sources. Global and Indian data. Plastic waste management Rules (India). Responsibility of waste generators, Local bodies, producers, Importers and Brand Owners. Marking and labeling Rules. Global Rules and Regulations. Global Policy. Global Plastic waste management and its impacts. Global examples.			
UNIT – III: Health and Environmental Impact.			
Health and Environmental Impact. Impact of Plastic pollution on marine life. Impact on wildlife.			
UNIT–IV: Management Practices			
Plastic waste management practices. Recycling and waste plastics. Mechanical and feedstock recycling. Pyrolysis. Waste to energy. Use of plastics in Road construction. Landfill and other other applications.			
UNIT –V: Resource Recovery and Circular Economy			
Alternate materials to plastics - green alternatives. Biodegradable plastics. Greener plastic products. Bio-based plastics. Quantify materials as green. Plastics resource recovery and circular economy. Case studies.			

Books and References Recommended

1. Velis, C. A. (2014). Global recycling markets-plastic waste: A story for one player–China. Int Solid Waste Assoc—Glob Waste Manag Task Force, 1-66.
2. Prevent Marine Plastic Litter - Now! - An Iswa Facilitated Partnership To Prevent Marine Litter, With A Global Call To Action For Investing In Sustainable Waste And Resources Management Worldwide. (2017)
3. Kershaw, P. (2018). Exploring the potential for adopting alternative materials to reduce marine plastic litter.
4. Global Waste Management Outlook, UNEP (2015)
5. The Global E-waste Monitor 2014. Quantities, flows and resources. University United Nations (2015).

Online Resources:

1. https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/E-Learning/Moocs/Solid_Waste/W1/Plastic_recycling_ISWA_2014.pdf
2. https://marinelitter.iswa.org/fileadmin/user_upload/Marine_Task_Force_Report_2017/ISWA_report_interactive.pdf
3. https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/E-Learning/Moocs/Solid_Waste/Key_resources/Global_Waste_Outlook_2015.pdf

Course Title	ENVIRONMENTAL MONITORING LAB		
Course code	1ESTL06	No. of credits	03
Center/ Department	Center for Environment , IST, JNTUH		
Program	M.Sc. : Environmental Science and Technology		
Course type	Laboratory - I		
Course Outcomes (COs)	**At the end of course, the student will able to** **CO1:** Analyze and assess the soil quality **CO2:** Collect water samples analyze water and assess the quality of water. **CO3:** Assess the wastewater characteristics and suggest suitable treatment techniques. **CO4**: Collect the ambient air samples and analyze the air samples.		

ANALYSIS OF PHYSICAL AND CHEMICAL PARAMETERS

Physical parameters of soil:

1. Moisture content
2. Bulk density
3. Specific gravity
4. Water holding capacity

Chemical parameters:

1. *pH*
2. *Electrical conductivity*
3. *Turbidity*
4. *Hardness – Calcium, Magnesium and total hardness*
5. *Alkalinity*
6. *Nitrates, Nitrites and Ammonical nitrogen*
7. *Phosphates*
8. *Sulfates by Spectrophotometric Method*
9. *Residual Chlorine*
10. *Dissolved Oxygen*
11. *Fluorides*
12. *Sodium*
13. *Potassium*
14. *Biological oxygen demand / organic matter*
15. *Chemical oxygen demand*
16. *Instrumentation analysis - HPLC, GC, AAS*

Air Pollution Monitoring:

1. NO_x
2. SO_x
3. Particulate matter

Course Title	**ENVIRONMENTAL MICROBIOLOGY LAB**		
Course code	**1ESTL07**	No. of credits	3
Center/ Department	Center for Environment, IST, JNTUH		
Program	M.Sc. : Environmental Science & Technology		
Course type	**Laboratory - II**		
Course outcomes (COs)	**After completion of course the students will be able to** **CO1:** demonstrate skills of different techniques of isolation, purification, cultivation, preservation and enumeration of microorganisms. **CO2:** determine cultural characteristics and staining of microorganisms. **CO3:** determine cardinal temperature and pH for growth of microorganisms and antibiotic sensitivity.		

General techniques of microbiology

1) Media preparation
2) Sterilization Inoculation
3) Cultivation of microorganisms
4) Isolation of microorganisms
5) Preservation of microorganisms
6) Ubiquitous nature of microorganisms.
7) Isolation and enumeration of air-borne bacteria.
8) Isolation and enumeration of green algae
9) Isolation and enumeration of fungi
10) Enrichment of purple non-sulfur bacteria

Characterization of microorganisms

11) Cultural characteristic of microorganisms
12) Staining of microorganisms
13) Bacterial growth curve
14) Effect of P^H and temperature on microbial growth
15) Kirby-Bauer test.

Determination of microbial quality of potable water

16) Standard plate count.
17) Standard coliform test.
18) Presence absence test.
19) Fecal coliform test.
20) 7hr FC test.
21) Membrane filtration test.
22) Enumeration of coliform bacteria by MPN method.
23) H2S strip test.

I Year - II SEMESTER

Course Title	**AIR POLLUTION & CONTROL TECHNOLOGIES**		
Course code	**2ESTPC09**	No. of credits	03
Center/ Department	Center for Environment , IST, JNTUH		
Program	M.Sc. : Environmental Science & Technology		
Course type	**Program Core IV**		
Course Outcomes (COs)	**At the end of the course, the Student will be able to** **CO1:** List the air pollutants, their resources, effects and can explain about the turbulence and reasons for Indoor air pollution **CO2:** Explain atmospheric dispersion equation and calculate the ground concentration of the pollutants due to stack emissions. Student will be able to explain the ambient air sampling and stack sampling techniques **CO3:** List and describe and explain the design criteria for different air pollution control techniques **CO4:** Explain the pollution emissions from two stroke and four stroke engines and the type of fuel and air pollution, existing vehicular pollution control technologies and need for improvement **CO5:** Explain about sources of noise pollution, impact of meteorological aspects on noise preparation and the noise measurement and control techniques		

UNIT I: CLASSIFICATION AND PROPERTIES OF AIR POLLUTANTS

Emission sources -major emissions from Global sources -importance of anthropogenic sources- behavior and fate of air pollutants- photochemical smog effects of air pollution health, vegetation and materials damage in India air pollution standards -different types of terrain – effects of terrain features on atmosphere – mechanical and thermal turbulence- Indoor air pollution.

UNIT II: METEOROLOGICAL ASPECTS OF AIR POLLUTION DISPERSIONS

Temperature lapse Rates and Stability, wind velocity and turbulence, Plume behaviour dispersion of air pollutants- solutions to the atmospheric dispersion equation - the Gaussian Plume Model. Air pollution sampling and measurement- types of pollutant sampling and measurement- Ambient air sampling- collection of gaseous air pollutants- collection of particulate pollutants- stock sampling, analysis of air pollutants-sulphur dioxide- nitrogen dioxide, carbon monoxide, oxidants and ozone- hydrocarbons and particulate matter (Suspended particulate matter(SPM), $PM_{10,}$ $PM_{2.5,}$ PM_1), Air pollution modelling.

UNIT III: CONTROL METHODS

Sources- correction methods--particulate emission control- gravitational settling chambers- cyclone separators- fabric filters- electrostatic precipitators- wet scrubbers--control of gaseous emissions- adsorption by solids- absorption by liquids- combustion, condensation – control of SO_2 emission – desulphurization of flue gases – dry methods – wet scrubbing methods. Control of sulphur dioxide emission- desulphurization of flue gases- dry methods- wet scrubbing methods- control of nitrogen oxides- modification of operating conditions- modification of design conditions- effluent gas treatment methods- carbon monoxide control- control of hydrocarbons.

UNIT IV: VEHICULAR AIR POLLUTION

Genesis of Vehicular emissions- Natural Pollution- Gasification of Vehicles- Point sources of Air Pollution from automobiles- Fuel tank, carburettor, crankcase- Exhaust emissions- Mechanism of Origin of air pollution from automobiles. Automobile air pollution – Indian Scenario- Population and pollution loads of vehicles- Automobile Pollution Control- Control at sources- Exhaust gas treatment devices- Alternate fuels comparison- Thermal Reactor- Catalytic Converter- Automobile Emission Control- Legal measures.

UNIT V: NOISE POLLUTION

Sources of noise pollution – measurement of noise and indices – effect of meteorological parameters on noise propagation- noise exposure levels and standards – noise control and abatement measures – impact of noise on human health.

Books Recommended

1. Air pollution control engineering / edited by Lawrence K. Wang, Norman C. Pereira, Yung-Tse Hung; consulting editor, Kathleen Hung Li. 2004
2. Air Pollution, H.C.V.Rao, 1990, McGraw Hill Co.
3. Environmental Pollution Control, C.S.Rao, Wiley Eastern Ltd.,1993
4. Air Pollution, M.N.Rao McGraw Hill 1993.

Reference Books:

5. Fundamentals of Air Pollution, Samuel, J.W., 1971, Addison Wesley Publishing Co.
6. Air Pollution, Kudesia, V.P. International Student Edition McGram-Hill-KosakushaLtd.,Tokyo.
7. Fundamentals of Environmental Pollution, Krishnan KhannanS. Chand& Company Ltd.,1994
8. Environmental Air Analysis, Trivedi&Kudesia, Akashdeep Pub.1992
9. Air Pollution Control and Engineering, De Nevers, McGraw- Hills, 1993
10. Energy Technology and the Environment AtilioBisio, Sharan Boots, Wiley Encyclopaedia Series in Environmental Science
11. Noise Pollution -VandanaPandey, Meerut Publishers,1995

Online Resource:

1. Guidelines for the Measurement of Ambient Air Pollutants. CPCB. (MoEF, Govt. of India) Website: http://www.cpcb.nic.in

Course Title	**ENVIRONMENTAL BIOTECHNOLOGY**		
Course code	**2ESTPC10**	No.of credits	3
Center/Department	Center for Environment, IST, JNTUH		
Program	M.Sc. : Environmental Science & Technology		
Course type	**Program Core V**		
Course outcomes (COs)	**At the end of the course, the Student will be able to** **CO1:**Explain various mechanisms in which microorganisms help plants by providing nutrients like Nitrogen, Phosphorous and also by helping in their uptake. They will be able to list out microbes which can be applied as biofertilizers and biopesticides. They will be able to explain the mechanism of biological control. They will be able to suggest appropriate biofertilizers and biocontrol agents for different crops/soils. **CO2:**They will be able to draw a flow chart explaining the principle and different components of biosensor. They would classify biosensors based on different criteria. They will explain, differentiate and indicate applicability of different transducing principles for biosensors. They will explain the working of different specific biosensors for glucose, ammonia, BOD, methane and mutagen. They would able to suggest appropriate biochemical recognition element and transducer to be used for biosensors of any analyze of interest. **CO3:**Explain the necessity for renewable sources of energy need for energy production from waste and non-conventional fuels like methane(biogas) hydrogen and ethanol and the current technologies, applications and challenges. **CO4:**Explain various mechanisms of microbial augmentation of oil recovery, overcoming problems in secondary oil recovery. Students will be able to explain the role microorganisms can play in biodiesel production and also in transesterification of vegetable oils. Students will be able to explain the mechanism, limitations and application of bioelectricity generation through microbial fuel cells. **CO5:** Explain the role of microorganisms in the biomineralization process in the natural environment. They will be able to suggest the application of struvite, halite and calcite forming microbes in the field of construction and environmental management		

UNIT I: BIO FERTILIZERS AND BIOLOGICAL CONTROL

PGPR bacteria, general mode of action of plant growth promoting microorganisms, Biofertilizers - Biological nitrogen fixation, phosphate solubilization,VAM fungi and crop productivity, Biological control-Microbial insecticides, (Microorganisms like Bacillus species, viral insecticides, certain fungi like Metarhiziumanisopliae). Biocontrol of plant pathogens. Microorganisms and mechanisms involved-amensalism, competition, predation and parasitism,antibiosis, siderophore production; Integrated Pest Management**.**

UNIT II: BIO-INDICATORS AND BIOSENSORS

Plankton and hydrophyte community as indicators of water pollution. Diversity index in evaluation of water quality; species richness & species evenness. Determination of microbiological quality of potable and recreational waters. Indicators of air pollution. Microbial biosensors – definition, advantages and limitations, different components of biosensor, various transducer principles. (conductometric, potentiometric, amperometric, optical,). Specificbiosensors-glucose, ammonia gas, BOD, methane and mutagen sensor

UNIT III: MICROBIAL BIOFUELS-1

Scope and importance of renewable sources, energy from waste materials, history of bio-fuels, production of non-conventional fuels – methane (biogas), hydrogen and ethanol; Types of biomass (e.g. wood waste, forestry residues, agricultural residues, organic municipal solid waste), available resources and microorganisms involved, biochemical conversion process, factors affecting, current technologies, applications and challenges.

UNIT IV: MICROBIAL BIOFUELS 2

Use of microorganisms in petroleum augmentation and recovery; Bio-diesel from microbial sources. Microbial fuel cells- definition, types, methodology and technology involved applications and environmental impact. Concept of Biorefineries

UNIT-V MICROBIAL BIOMINERALIZATION

Microbial biomineralization-Introduction, importance of biomineralization in natural environments, microbes involved and environmental applications, calcite, halite and struvite production, application in- bioconcrete and biomotor, soil stabilization, nutrient recovery.

Books Recommended

1. Elements of biotechnology 2019 2nd edition. P.K.Gupta, Rastogi. Rastogi publication.
2. Industrial microbiology- L. E. Cassida, 2016, 2nd Edition, New Age International (P) Ltd.
3. Industrial Microbiology-Prescott and Dunn. 4th Edition, 2006, Cbs Publishers & Distributors
4. Microbial Biotechnology – Glazer, A.N; Nikaido, H-2007-2nd edition Cambridge University Press

Reference Books:

1. Biotechnology – A new industrial revolution PrentisS.Orbis Publishing Ltd., London.
2. Review articles published in annual reviews, current opinion in microbiology etc. R.C. critical reviews in microbial.
3. Review articles in Adv. Microbial physiol; Adv. Appl microbial; Bacteriol reviews, microbial reviews etc.

Course Title	ENVIRONMENTAL GEOMATICS		
Course code	2ESTPC11	No. of credits	3
Center/ Department	Center for Environment , IST, JNTUH		
Program	M.Sc. : Environmental Science & Technology		
Course type	Program Core VI		
Course outcomes (COs)	**At the end of the course, the Student will be able to** **CO1**: Validate the satellite Remote sensing process, Atmospheric interactions and energy interactions **CO2**: Formulate the Air and space borne sensors with respect to spectral and radiometric resolutions. Appraise satellite navigation systems, outer space explorations, chandrayan and Mangalyan. **CO3**: Illustrate the visual and digital image processing techniques **CO4**: Examine the GIS process and fundamental requirements **CO5**: Analysis of GIS data process, validation, Accuracy and output process		

UNIT I: REMOTE SENSING – BASIC PRINCIPLES

Introduction, Electromagnetic Remote Sensing Process, Physics of Radiant Energy: Nature of Electromagnetic Radiation, Electromagnetic Spectrum. Energy Source and its Characteristics, Atmospheric Interactions with Electromagnetic Radiation: Atmospheric Properties, Absorption Ozone, Atmospheric Effects on Spectral Response Patterns. Energy Interactions with Earth's Surface Materials: Spectral Reflectance Curves. Cossine Law.

UNIT II- REMOTE SENSING PLATFORMS AND SENSORS

Introduction, Satellite System Parameters: Instrumental Parameters, Viewing Parameters. Sensor Parameters, Spatial Resolution, Spectral Resolution, Radio metric resolution. Imaging Sensor Systems: Multispectral imaging sensor systems, thermal sensing systems, microwave image systems. Latest Trends in Remote Sensing Platforms and sensors: Examples of different satellites and sensors.

UNIT III- VISUAL IMAGE INTERPRETATION AND DIGITAL IMAGE PROCESSING

Introduction, Types of Pictorial Data Products, Image interpretation strategy, Process of Image Interpretation, Interpretation of Aerial Photo, Basic elements of Image Interpretation, Application of Aerial Photo Interpretation, Interpretation of Satellite Imagery, Key Elements of Visual Image Interpretation, Concept of Converging Evidence. Basic Character of Digital Image, Preprocessing, Image Registration, Image Enhancement Techniques, Image Classification. Image classification and GIS.

UNIT IV- FUNDAMENTALS OF GIS

Introduction, Roots of GIS, Overview of Information System, The Four Ms, Contribution Disciplines, GIS Definitions and Terminology, GIS Queries, GIS Architecture, Theoretical Models of GIS. Theoretical Framework for GIS, GIS Categories, Levels/Scales of Measurement. GIS data Types, Spatial data models, Comparison of Raster and Vector models, and Topology. GIS data Input and Storage: Introduction, The data stream, Data input methods: Keyboard entry, Manual digitizing, Scanning and automatic digitizing; GPS for GIS data capture; Storage of GIS database.

UNIT V- GIS DATA- EDITING, QUALITY, ANALYSIS AND OUTPUT

Data editing, Detecting and correcting errors, Data reduction and generalization, Edge matching and Rubber sheeting. Components of data quality, Accuracy, Precision and resolution Consistency, Completeness, Sources of error in GIS; Data Analysis- Format and Data medium conversion, spatial measurement methods, Reclassification, buffering techniques and overlay analysis; GIS output- Maps as output and graphical outputs. GIS applications.

Books Recommended

1. M.Anji Reddy, Text book of Remote sensing and GIS by, BS Publications, Hyderabad.
2. Lillesand, T.M. and Kiefer R.W. Remote Sensing and Image Interpretation, John Wiley and Sons, Inc, New York, 1987.
3. Principles of Geographic Information Systems by John Jensen and Ryan
4. Remote Sensing: Principles and Applications - Kindle edition by Floyd F. Sabins.
5. Fundamentals of Geographic Information Systems by Michael N DeMers. Published By john Wiley & Sons Inc., 3rd edition, 2008.

Course Title	**INSTRUMENTAL METHODS OF ANALYSIS**		
Course code	**2ESTPE12**	No. of credits	03
Center/ Department	Center for Environment , IST, JNTUH		
Program	M.Sc. : Environmental Science & Technology		
Course type	**Program Elective II**		
Course outcomes (COs)	**At the end of the course, the Student will be able to** **CO1:**To develop a basic knowledge about the analytical errors and uncertainties and basic principle, operation and applications of pH meter, Conductivity meter and ion selective electrodes **CO2:** understand the principles, operation and applications of UV-VIS and Infra-red spectrophotometer **CO3:** understand the principles, operation and applications of AAS and atomic emission spectrophotometer **CO4:** understand the principles, operation and applications of chromatographic techniques(GC,HPLC, GCMS,LCMS) **CO5:** understand the principles, operation and applications of U.V fluorimetry, laser fluorimetry, scintillation counters, α, β counters, gamma spectrometry.		

UNIT I INTRODUCTION:
Type of Instrumental methods of Analysis – accuracy, precision, types of errors Uncertainties i Instrumental measurements – Sensitivity and detection limit for instruments. Measurement o pH and Conductivity, Ion selective electrodes
UNIT II UV- VISIBLE SPECTROSCOPY INFRARED SPECTROSCOPY:
Electromagnetic spectrum- frequency - wave number– Absorptivity – deviations from Beer' law – single & double beam spectrophotometer - Instrumentation –Photometric accuracy - Qualitative and quantitative analysis. Infrared spectroscopy – Theory, Instrumentation & applications.
UNIT III ATOMIC ABSORPTION AND EMISSION SPECTROSCOPY:
AAS- Principle – Instrumentation – Interference – applications; ICP-Theory, Instrumentation & applications; Flame photometer-Principle Instrumentation and applications.
UNIT IV CHROMATOGRAPHY:
Column, ion exchange, TLC, GLC, HPLC, GCMS, LCMS: Principles and applications Instrumentation: detectors, columns, injectors - temperature programming- isocratic and gradient programming - qualitative and quantitative analysis
UNIT V RADIOACTIVE TECHNIQUES:

Radio activity- Half-life decay, U.V fluorimetry, laser fluorimetry, scintillation counters, α, β counters, gamma spectrometry.

Books Recommended

1. **R.A. Day** 7 A.L. Underwood, Quantitative analysis, Prentice-Hall of India Pvt. Ltd., 1985.
2. Skoog & West, Fundamentals of Analytical Chemistry, 1982.
3. Hobert H. Willard, D.L. Merrit & J.R.J.A. Dean, Instrumental methods of analysis, C.B.S Publishers and Distributors, 1992.
4. Vogel, Textbook of quantitative inorganic analysis, 1990.
5. Ewing, Instrumental Methods of Chemical Analysis, 1992, McGraw Hill
6. Instrumental Methodology of Analysis by Chatwal Anand, Himalaya Publishing House.
7. Separation chemistry (2006), R.P Budhiya, PP424. New age international (p) Ltd.

Course Title	**BIOREMEDIATION TECHNOLOGIES**		
Course code	**2ESTPE12**	No. of credits	3
Center/Department	Center for Environment, IST, JNTUH		
Program	M.Sc.. : Environmental Science & Technology		
Course type	**Program Elective II**		
Course outcomes (COs)	**At the end of the course, the Student will be able to** **CO1:** define and explain what, when, where, why and how of bioremediation. List out advantages and its application. They will be able to explain the phenomena of biodegradation, acclimation, detoxification, activation, co-metabolism and biotransformation and recalcitrance and their significance in bioremediation. They would be able to explain the concept of bio-availability, the effect of chemical structure on biodegradation and predict biodegradability and the products of biodegradation of any given compound. **CO2:** classify bioremediation into different types, based on different criteria. They will also be able to list and explain different factors which aid or are detrimental to bioremediation and thus identify criteria to be met for bioremediation. They will be able to list explain different methods available for assessing biotreatability and also analyze, differentiate and explain relative advantage, disadvantages and application. **CO3:** list and describe different bioremediation technologies, bringing about the differences between them and practical application. They will be able to suggest suitable bioremediation technologies for specific pollutants/environments. **CO4:** define phytoremediation and explain physical, chemical and biological mechanism of phytoremediation the students will be able to suggest the type of plants /mechanism to be applied for different pollutants/environments. **CO5:** explain how oil pollution can be bioremediated. The students will be able to explain the mechanism of metal bioremediation. The students will be able to outline bioremediation technologies for various inorganic pollutants like arsenic, chromium, selenium, uranium, nitrate, cyanide and mercury.		

UNITI: INTRODUCTION TO BIOREMEDIATION
What is Bioremediation, Constraints, advantages and applications. Biodegradation, Acclimation, detoxification, activation, cometabolism and biotransformation, bio-availability, effect of chemical structure on biodegradation, recalcitrance, predicting products of biodegradation.
UNITII: TYPES OF BIOREMEDIATION AND FACTORS AFFECTING
Types of bioremediation (definition) - Natural (attenuation) and engineered, ex-situ and in-situ, Bioaugmentation and biostimulation, solid phase and slurry phase bioremediation. Criteria to be met for considering bioremediation-factors affecting bioremediation, treatability studies for bioremediation
UNITIII:SPECIFIC BIOREMEDIATION TECHNOLOGIES
Application, Advantages and disadvantages of specific bioremediation technologies-landfarming, prepared beds, biopiles, composting, bioventing, biosparging, pump and treat method, biofilters, biotricking filters, bioscrubbrers, bioreactors for bioremediation.
UNITIV:PHYTOREMEDIATION
What is phytoremediation? Basic physiological processes involved, Mechanism of Phytoremediation, Phytosequestration, Phytovolatilisation (evapotranspiration), Phytodegradation: Rhizofiltration: Phytoextraction, Phytostabilization Phytotransformation, Phytomining. Maintenance of hydraulic control using deep rooted tree systems. Constructed wetlands.
UNITV:BIOREMEDIATION OIL SPILLS AND METALS
Bioremediation of oil pollution, advantages and limitations. Biostimulation, Bioaugmentation. Microbial inoculants. Bioremediation of metals and other inorganic pollutants: Biosorption and bioaccumulation,Reduction,Solubilization/Oxidation,Precipitation,Methylation,Individualpollutants(arsenic,chromium, uranium, cyanide,and mercury)
Reference Textbooks: 1. Bioremediation1994.Baker,K.HandHerson,D.S.McGrawHill,Inc.NewYork 2. Biotreatment of Industrial Hazardous Waste 1993,M.V.Levin & Gealt, M.A McGrawHill.Inc. 3. Biodegradation and Bioremediation 1999(2ndediton). Martin Alexander, Elsevier Science & Technology. 4. Environmental Microbiology 2001. RainaM.Maier, IanL.Pepper, AcademicPress. 5. Bioremediation Engineering. J.T.Cookson, Mc.GrawHill Inc.

Course Title	ENVIRONMENTAL LAW & AUDIT		
Course code	2ESTPE12	No. of credits	3
Center/ Department	Center for Environment , IST, JNTUH		
Program	M.Sc. : Environmental Science & Technology		
Course type	Program Elective II		
Course Program outcomes (COs)	**At the end of the course, the student will be able to** **CO1:** Summarize the Air, Water wild life and forest acts. **CO2:** Examine the Solid waste management and related issues. **CO3:** Discuss about Biomedical and Hazardous waste management. **CO4:** Summarize the EIA and Biodiversity Act. **CO5:** Examine the Coastal areas and related environmental issues & acts.		
UNIT I: OVERVIEW AND ENVIRONMENTAL PROTECTION ACT (AIR, WATER, WILDLIFE, FOREST)			
Provisions of Act, Rules to regulate Environmental Pollution, Powers of entry and inspection, Power to take sample, Environmental laboratories; Air pollution, Air (prevention and Control of Pollution) Act; Water (prevention and Control of Pollution) Act, Functions of CPCB, Functions of SPCB; Wild Life Protection Act; Forest Conservation Act.			
UNIT II: MUNICIPAL SOLID WASTE Management Rules			
Municipal waste Collection, segregation, storage, transportation, Processing, Disposal facilities; Specifications for landfill sites, Pollution prevention, Water quality monitoring, Ambient Air Quality Monitoring, Plantation at landfill site, Closure of landfill site, Special provisions for hilly areas; Standards for composting, treated leachates and incinerations;			
UNIT III: BIOMEDICAL & HAZARDOUS WASTE MANAGEMENT AND HANDLING RULES			
Segregation, packaging, Transportation, storage, Treatment, Disposal and Prescribed authority. Biomedical waste Act; Hazardous waste Management and Handling rules,			
UNIT IV: BIODIVERSITY ACT AND EIA			
The convention on biological diversity, Biodiversity authority, Biological diversity act, Biodiversity loss, Major threats, protected areas and Biosphere reserves, Pressures on biodiversity conservation, Conservation of biodiversity; Environmental Impact assessment notification, Environmental Management plan, Environmental clearance process.			
UNIT V: COASTAL REGULATION ZONE RULES			
Prohibited activities, Permissible activities, procedure for clearance of Permissible activities, preparation of coastal zone management plans, Enforcement of CRZ and rules, Classification of the CRZ, Norms for regulation of activities.			

Books Recommended

1. Environmental Impact Assessment: Theory and Practices by Dr.M.Anji Reddy, BS Publications.
2. Environmental Impact Assessment by Y.Anjaneyulu, BS Publications
3. Environmental Science and Engineering by J.Glyan and Gary W, Hein Ke - Prentice Hall Publishers.

Course Title	GLOBAL ENVIRONMENTAL ISSUES		
Course code	2ESTOE13	No. of credits	3
Center/ Department	Center for Environment , IST, JNTUH		
Program	M.Sc. : Environmental Science & Technology		
Course type	Open Elective II		
Course Program outcomes (COs)	**At the end of the course, the student will be able to** **CO1:** Identify the environmental issues and related laws **CO2:** Examine the national and international environmental protection movements and related issues. **CO3:** Discuss about climate change issues and energy scenarios **CO4:** Summarize the land degradation activities and nuclear energy and related issues. **CO5:** Examine the different types of disasters and importance of Green building concepts.		

UNIT I: OVERVIEW OF ENVIRONMENTAL ISSUES

Human environmental Interactions- Global Environmental Agreements & Movements - Stockholm and Beyond – Evolution of International Environmental Laws- making international, national environmental agreements.

UNIT II: ENVIRONMENTAL MOVEMENTS:

Global and national movements of Significance impact: RAMSAR Convention- Green Belt movement- GreenPeace – Chipko movement- Narmada Bachao Andolan – Silent valley- Doon valley and related issues / case studies

UNIT III: CLIMATE CHANGE AND ENERGY CRISIS

Sea level Change – primary and secondary impacts- Adapting to Sea level changes. Global Warming- Fossil fuels- Greenhouse gases- Global and national scenario. National Action Plan on Climate Change. (NAPCC). Climate Change and Biodiversity loss;
Energy requirements- Developed- Developing- Under Developed nations. Cases studies of International and National importance.

UNIT IV: LAND DEGRADATION AND NUCLEAR ISSUES

Land pollution • Desertification - Soil — Soil conservation • Soil erosion • Soil contamination • Soil salination. Mining- reclamation of mined area. Desertification-case studies;
Nuclear issues —Nuclear power • Nuclear weapons • Nuclear and radiation accidents • Nuclear safety • High-level radioactive waste management.

UNIT V: NATURAL & ANTHROPOGENIC DISASTERS AND CONTEMPORARY ISSUES
Natural Disaster : Volcanoes- Landslides- Tsunami- Forest Fires – Case studies .Anthropogenic : Oil spills; Green Buildings- Genetic pollution- Genetically modified food controversies. Intensive farming Monoculture. Health and Diseases- Epidemics and Famines.
Books Recommended 1. Global environmental issues: a climatological approach by David D. Kemp, Taylor and Francis.

Course Title	BIOMASS CONVERSION AND TECHNOLOGIES		
Course code	**2ESTOE13**	No. of credits	3
Center/ Department	Center for Environment , IST, JNTUH		
Program	M.Sc. : Environmental Science & Technology		
Course type	**Open Elective II**		
Course Program outcomes (COs)	**At the end of the course, the student will be able to** **CO1**: To have an exposure on the types of biomass, its surplus availability and characteristics. **CO-2**: Analyze the technologies available for conversion of biomass to energy in terms of its technical competence and economic implications. **CO-3**: A practical understanding on the various biomass energy conversion technologies and its relevance towards solving the present energy crisis.		
UNIT I: ORIGIN OF BIOMASS			
Resources - Classification and characteristics - Techniques for biomass assessment - Application of remote sensing in forest assessment – Biomass estimation.			
UNIT II: THERMOCHEMICAL CONVERSION			
Different processes - Direct combustion – Incineration – Pyrolysis - Gasification and liquefaction - Economics of thermochemical conversion.			
UNIT III: BIOLOGICAL CONVERSION			
Biodegradation and biodegradability of substrate – Biochemistry and process parameters of biomethanation - Biogas digester types - Digester design and biogas utilization. Biomethanation Process - Economics of biogas plants with their environmental and social impacts - Bioconversion of substrates into alcohol - Methanol & ethanol Production -Organic acids – Solvents - Amino acids - Antibiotics etc.			
UNIT IV: CHEMICAL CONVERSION			
Hydrolysis & hydrogenation - Solvent extraction of hydrocarbons- Solvolysis of wood - Biocrude and biodiesel - Chemicals from biomass.			
UNIT V: POWER GENERATION			
Utilisation of gasifier for electricity generation - Operation of spark ignition and compression ignition engine with wood gas – Methanol - ethanol & biogas - Biomass integrated gasification/combined cycles systems - Sustainable co-firing of biomass with coal - Biomass productivity - Energy plantation and power programme.			

Books Recommended

1. Biotechnology and Alternative Technologies for Utilization of Biomass, Chakravarthy A
2. Biogas Systems: Principles and Applications, Mital K.M
3. Biomass Energy Systems, Venkata Ramana P and Srinivas S.N
4. Gasification Technologies, A Primer for Engineers and Scientists Rezaiyan. J and N. P. Cheremisinoff.
5. Biomass Gasification – Principles and Technology, Tom B Reed, Noyce Data Corporation, 1981.
6. Bio Energy Technology Thermodynamics and costs, David Boyles, Ellis Hoknood Chichester,1984.
7. Khandelwal KC, Mahdi SS, Biogas Technology – A Practical Handbook, Tata McGraw Hill, 1986.
8. Bio Energy for Rural Energisation, Mahaeswari, R.C. Concepts Publication,1997
9. Best Practises Manual for Biomass Briquetting, I R E D A, 1997.
10. The briquetting of Agricultural wastes for fuel, Eriksson S. and M. Prior, FAO Energy and Environment paper, 1990.
11. Thermochemical Characterization of Biomass, Iyer PVR , M N E S

Course Title	**URBAN LAND USE PLANNING AND SMART CITIES**		
Course code	**2ESTOE13**	No. of credits	3
Center/ Department	Center for Environment , IST, JNTUH		
Program	M.Sc. : Environmental Science & Technology		
Course type	**Open Elective II**		
Course Program outcomes (COs)	**At the end of the course, the student will be able to** **CO1:** Identify methods and tools for Land use, built environment, and zoning criterion. **CO2:** Classify relevance of Geomatics in evaluating Land suitability, capability in decision making system. **CO3:** Compose Urban growth models in assessing alternative land use for environmental modeling. Discuss sustainability of Land management, Net farm profitability, and Principles of ecology for planners. **CO4:** Summarize the need of smart cities and the role of Govt. and stakeholders. **CO5:** Examine the smart cities spatial planning with case studies.		

UNIT I: INTRODUCTION TO URBAN PLANNING WITH SPECIAL REFERENCE TO ENVIRONMENTAL ISSUES

Study of the methods and tools for managing land use and the built environment. Comprehensive Plan, Zoning Criteria and guidelines, regional, and state-level plans and socio-economic issues.

UNIT II: GEOMATICS FOR LAND USE PLANNING AND ENVIRONMENTAL MONITORING

i. Land use System: Environmental inputs and impacts, economic inputs and outputs. Role of Geomatics in Land Evaluation and Suitability for land use planning.
ii. Land Capability classification and preference of land use.
iii. Decision Support System for land use planning

UNIT III: URBAN STUDIES USING GIS

i. Fundamentals of GIS and statistics.
ii. GIS-based land use and urban growth models, basins (stream and runoff water quality model)
iii. Visualization and impact assessment models for alternative land use

UNIT IV: SMART CITIES - I

i. Benchmarks; Smart city scheme; Infrastructure pillars—Social, Physical, Institutional and Economic; Instruments; Demand; Citizen participation; Role of Government; conditions precedent for smart city development; Financial architecture; Industrial promotion;

ii. Smart city reference frame wok and Implementation framework; smart mobility; smart environment; smart living; role of GIS and smart services.

UNIT V: SMART CITIES - II

i. smart city model; principles and spatial planning; Instrumentation; Transportation ; water distribution; sewage treatment; Waste management; Smart communication; Quality assurance; Resilience-- the use of IT; Energy efficiency; Optimisation techniques; Zero emissions; sustainability;

ii. **Case studies**: Singapore; India; Songdo; Lavasa; and Vienna.

Books Recommended

1. Atmospheric Chemistry and Physics: From Air Pollution to Climate Change, 2ndEdition, John H. Seinfeld and Spyros N. Pandis, 2006, ISBN 978-0-471-72018-8
2. Fundamentals of Atmospheric Modeling, 2nd Edition, Mark Z. Jacobson, 2005, ISBN 978-0-521-54865-6
3. Air Quality Modeling, Vol. I-III. Paolo Zannetti, EnviroComp/A&WMA.
4. Atmospheric Chemistry and Physics of Air Pollution. Seinfeld, John H., John Wiley and Sons, Inc., New York, 1986.
5. Introduction to Boundary Layer Meteorology. Stull, Roland B., Kluwer Academic Publishers,

Course Title	ENVIRONMENTAL GEOMATICS LAB		
Course code	2ESTL14	No. of credits	3
Center/ Department	Center for Environment , IST, JNTUH		
Program	M.Sc. : Environmental Science & Technology		
Course type	Laboratory - III		
Course outcomes (COs)	**At the end of the course, the Student will be able to** **CO1:** Master and apply methods of interpreting and analyzing remote sensing data. **CO2:** Use GIS to identify, explore, understand, and solve spatial problems Demonstrate GIS modeling skills. **CO3:** Demonstrate critical thinking skills in solving geospatial problems. Design and implement a GIS project. **CO4:** Use queries in GIS Analysis Formulate applications of GIS technology.		

1. Study of toposheet and base map preparation;
2. Description of satellite and sensor details of the imagery used for thematic mapping;
3. Land use / land cover map preparation;
4. Field visits for finalization of land use / land cover map and soil map;
5. Scanning / digitization of maps;
6. Digital image display; image enhancement;
7. Image registration
    a. Ground Control points from toposheets (GCP)
    b. Geo referencing
8. Image classifications for land use / land cover using ERDAS / PCI Geomatica / ENVI.
9. Digital Mapping: GIS Software, ARC GIS and Geo-Server.

Course Title	**ENVIRONMENTAL BIOTECHNOLOGY LAB**		
Course code	**2ESTL15**	No. of credits	3
Center/Department	Center for Environment, IST, JNTUH		
Program	M.Sc. : Environmental Science & Technology		
Course type	**Laboratory IV**		
Course outcomes (COs)	**After completion of course the students will be able to carry out:** **CO1:** Isolation of potential of biofertilzers and determination of activity **CO2:** Isolation of antibiotic producing microorganisms **CO3:** Application of microorganisms for bioelectricity generation using Microbial Fuel cells **CO4: U**tilization of microorganisms for various environmental applications like biodiesel production, microbial concrete, nutritional recovery from industrial effluents **CO5:** select an appropriate test and execute and report abot microbiological quality of potable water.		

~~1.~~1) Isolation of phosphate solubulizing bacteria
~~2.~~2) Determination of ~~Nitrogenase~~nitrogenase activity
~~3.~~3) Crowded plate technique for isolation of antibiotic producing microorganisms
~~4.~~4) Microbial fuel cells for bioelectricity generation.
~~1) Biodiesel production by using microorganisms~~
~~5.~~5) Crystal forming bacteria for nutrient recovery from industrial effluents
~~6.~~6) Bioaugmentation for composting
~~7.~~7) Microbial concrete
~~8.~~8) Screening for amylase production and isolation of amylase producing microbes
~~9.~~9) Screening for protease production and isolation of protease producing microbes
~~10.~~10) Screening for chitinase production isolation of chitinase producing microbes
~~11.~~11) Screening for lipase production isolation of lipase producing microbes
~~2) Biomortar~~
12) Screening for pectinase production isolation of pectinase producing microbes
13) Sand plugging test for MICP
14) Photoproduction of hydrogen by purple nonsulfur bacteria
~~3)~~15) Carbon sequestration by purple nonsulfur bacteria

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II YEAR - III SEMESTER

Course Title	**ENVIRONMENTAL IMPACT ASSESSMENT (EIA)**		
Course code	**3ESTPC17**	No. of credits	3
Center/ Department	Center for Environment , IST, JNTUH		
Program	M.Sc. : Environmental Science & Technology		
Course type	**Program Core VII**		
Course outcomes (COs)	**At the end of the course, the student will be able to** **CO1:** Direct, Indirect, cumulative and induced environmental impacts at Regional, sectoral and project level. **CO2:** Data products, thematic maps, collateral data in planning and management of baseline data acquisition. **CO3:** Screening of environmental clearance, for category B&B2 industries and feasibility studies. **CO4:** Predicting impact of Air, Water, Noise, Socio economic status on environment. **CO5:** Environmental management plans on emission controls and green belt development and hazardous wastes.		

UNIT I: CONCEPTUAL FACTS OF EIA

i. Introduction, Definition and Scope of EIA, Objectives in EIA, Basic EIA Principles, and Classification of EIA: Strategic EIA (SEIA), Regional EIA, Sectoral EIA, Project Level EIA and Life Cycle Assessment, Project Cycle, Grouping of Environmental Impacts: Direct Impacts, Indirect Impacts, Cumulative Impacts and Induced Impacts. Significance of Impacts: Criteria/Methodology to Determine the Significance of the Identified Impacts.

UNIT II: BASELINE DATA ACQUISITION, PLANNING AND MANAGEMENT OF IMPACT STUDIES

i. Environmental Inventory, Data Products and Sources: thematic data, topographical data, collateral data and field data. Environmental Baseline Monitoring (EBM), Preliminary Study to determine impact significance, Environmental Monitoring network Design, Monitoring Stations, Air quality data acquisition, Water Quality data acquisition, soil data, socioeconomic data and biological data acquisition. Impact on Environmental Components: Significance of Impacts, Criteria to determine the significance of the identified Impacts.

ii. Conceptual Approach for Environmental Impact Studies, Proposal Development, Interdisciplinary Team Formations, Team Leader Selection and Duties, General Study Management, Fiscal Control.

UNIT III: OPERATIONAL ASPECTS OF EIA AND METHODS FOR IMPACT IDENTIFICATION

i. Screening: Application for Prior Screening for Environmental Clearance, Screening Criteria; Category A Projects, Category B Projects, Criteria for Classification of Category B1 and B2 Projects, Consistency with other Requirements and Siting Guidelines. Scoping Identification of Appropriate Valued Environmental Components (VEC), Identification o Impacts, Information in Form 1, Structure of a Pre-feasibility Report. Public consultation Appraisal, Decision Making, Post-clearance Monitoring Protocol.

ii. Background Information, Interaction-Matrix Methodologies: simple matrices, stepped matrices, development of a simple matrix, other types of matrices, summary observations on matrices, Network Methodologies: Checklist methodologies, simple checklists descriptive Checklists, summary observations on simple and descriptive Checklists.

UNIT IV: PREDICTION OF IMPACTS (AIR-WATER- NOISE- BIOLOGICAL AND SOCIO-ECONOMIC)

i. Air Environment: Basic information on air quality, Sources of Pollutants, effects of pollutions, Conceptual approach for addressing air environment impacts, Air quality standards, Impact Prediction, Impact significance.

ii. **Water Environment:** Basic Information on surface-Water Quantity and Quality, Conceptual Approach for Addressing Surface-Water-Environment Impacts, Identification of Surface-Water Quantity or Quality Impacts, Procurement of Relevant Surface-Water Quantity-Quality Standards, Impact Predictions, Assessment of Impact Significance.

iii. Noise Environment: Basic Information on Noise Key Federal Legislation and Guidelines, Conceptual Approach for Addressing Noise-Environment Impacts, Identification of Noise Impacts, Procurement of Relevant Noise Standards and/or Guidelines, Impact Prediction, Assessment of Impact Significance.

iv. **Biological Environment:** Basic Information on Biological Systems, Conceptual Approach for Addressing Biological Impacts, Identification of Biological Impacts, Description of Existing Biological Environment Conditions.

v. **Socio-Economic Environment:** Procurement of Relevant Legislation and Regulations, Impact Prediction, Assessment of Impact Significance.

UNIT V: ENVIRONMENTAL MANAGEMENT PLAN (EMP)

i. Case Study, identification of Impacts, EMP for Air Environment: Dust Control Plan, Procedural Changes, Diesel Generator Set Emission Control Measures, Vehicle Emission Controls and Alternatives, Greenbelt Development. EMP for Noise Environment,

ii. EMP for Water Environment: Water Source Development, Minimizing Water Consumption, Domestic and Commercial Usage, Horticulture, Storm Water Management. EMP for land Environment: Construction Debris, hazardous Waste, Waste from temporary Labour settlements.

Books Recommended

1. Environmental Impact Assessment : Theory and Practice by Dr.M.Anji Reddy
2. Textbook of Environmental Science & Technology by M.Anji Reddy, BS Publications, 2010
3. Man and Environment D.H.Carson 1976 Interactions Part I and III.
4. Environmental Impact Assessment by Harry W. Canter, McGraw Hill, 1996, 2nd edition.
5. Environmental Impact Assessment, 2003, Y.Anjaneyulu, B.S Publications
6. Technological guidance manuals of EIA. MoEF.

Course Title	**WASTE WATER TREATMENT TECHNOLOGIES**		
Course code	**3ESTPC18**	No. of credits	03
Center/ Department	Center for Environment , IST, JNTUH		
Program	M.Sc. : Environmental Science & Technology		
Course type	**Program Core VIII**		
Course outcomes (COs)	**At the end of the course, the Student will be able to** **CO1:** Describe the principles and process of various treatment systems for water and wastewater. **CO2:** Explain the characteristics of water and wastewater that must be considered during design of a treatment plant. **CO3:** Describe the treatment systems and the components comprising such systems, leading to the selection of specific process equipment items and advancement. **CO4:** Develop conceptual schematics required for the treatment of water and wastewater. **CO5:** Identify and formulate the treatment problems, design and conduct experiments and interpret generated data as necessary to obtain process performance data.		

UNIT I: WATER POLLUTANTS AND TREATMENT

Types and Sources, quality of water (water, sewage and industrial wastewater), various stages of water treatment flocculation and coagulation, Sedimentation, Filtration: slow and rapid sand filters, disinfection.

UNIT II: WASTEWATER TREATMENT

Characterization and degree of treatment-Self-purification in a stream, characteristics of waste water and treatment plant effluents, Dissolved oxygen, Esturine pollution **Primary treatment**: Screening, Grit removal, Neutralization, Equalization, Coagulation, Flocculation, Sedimentation, Flotation (oil & grease removal), Air stripping **Secondary treatment**-principles of waste treatment, basic kinetic equations, continuous flow treatment models, oxygen requirement in aerobic process, production of sludge. Conventional biological process: Activated Sludge Process (ASP), UASB, Trickling Filters and RBC, ***Nitrogen removal***: Nitrification and denitrification process, phosphorous removal. Low cost wastewater treatment: Aerated lagoons, stabilization ponds, oxidation ditches.

UNIT III: TERTIARY TREATMENT OF WASTEWATER

Tertiary treatment-ion exchange, ***Membrane separation Techniques***: Brief description of MF, UF, NF membranes. Reverse osmosis principle , Membrane materials , Types of membranes – Plate & frame , tubular, hollow fibre , spiral wound membranes, application of membranes in various industrial applications., ***electro chemical techniques***: electro dialysis, electro coagulation, ***Evaporators***: forced evaporation , Multiple effect evaporators – falling film , raising film , forced circulation , agitated thin film driers. Advanced oxidation process, photo catalysis, Ozonation, Fenton process, Hydrodynamic cavitation.

UNIT IV: SEWAGE TREATMENT AND DISPOSAL
Introduction, importance of sewage, Characteristics of sewage, Sewage treatment and disposal: Grit chamber, Sedimentation tanks, Secondary treatment: Activated sludge process, sludge digestion. Sludge disposal. Septic tank.
UNIT V: INDUSTRIAL WASTEWATER TREATMENT
Sources, Characteristics, methodology and process for the treatment of industrial wastes of sugar industry- beverage industry- tannery industry- textile mill waste industry- fertilizer plant-steel plant- oil refinery-paper and pulp mill. Legislation, Cleaner technologies: Water conservation, By-product recovery, Zero liquid discharge (ZLD). Case studies: Pharma/Chemical industry.
Books Recommended 1. Water Supply and Sanitary Engineering by Birdie G.S., Birdie J.S., Dhanpat Rai & Sons 2010. 2. A treatise on Rural, Municipal, and industrial water management KVSG Murali Krishna 3. Environmental sanitation (Social and Preventive medicine) Dr.P.V. Rama Raju & KVSG Murali Krishna. 4. Waste water engineering, treatment and reuse by Metcalf and eddy, fifth edition, Tata McGraw Hill. **Reference Text Books:** 1. Municipal and Rural Sanitation- Ehlers,V.M. & Steel,E.W., McGraw Hill Book Company Inc. Vth edition. 1987. 2. Environmental Sanitation, Ehlers, V.M., add Steel, E.W., McGraw-Hill Book Co., Inc. 1. Environmental pollution and Toxicology, Meera Asthana and Asthana D.K, Alka Printers (1994).

Course Title	ENVIRONMENTAL MODELLING		
Course code	3ESTPC19	No. of credits	03
Center/ Department	Center for Environment , IST, JNTUH		
Program	M.Sc. Environmental science and Technology		
Course type	Program Core IX		
Course outcomes (COs)	**At the end of the course, the Student will be able to** **CO1:** Explain the role of modeling in environmental sciences and management, its advantages and limitations. **CO2:** Describe main principles and approaches to surface and groundwater modeling software. **CO3:** Familiar with salt water intrusion principles and its control. **CO4:** Explain the main principles and approaches to air quality modeling software. **CO5:** Describe the applications of Air Quality modeling software.		

UNIT – I: WATER QUALITY AND MODELLING
Groundwater Occurrence: Groundwater hydrologic cycle, origin of groundwater, rock properties affecting groundwater, vertical distribution of groundwater, zone of aeration and zone of saturation, geologic formation as Aquifers, types of aquifers, porosity, Specific yield and Specific retention. Groundwater Movement: Permeability, Darcy's law, storage coefficient. Transmissivity, differential equation governing groundwater flow in three dimensions, groundwater flow equation in polar coordinate system. Groundwater flow contours their applications.
UNIT – II: WATER QUALITY AND MODELLING
Groundwater Quality. Groundwater Modelling: Groundwater Flow, Transport and transformation of contaminants in groundwater: processes, formulation of the governing equations and initial and boundary conditions, solutions for simple cases. Groundwater Basin Management: Concepts of conjunctive use, Case studies.
UNIT – III: SALT WATER INTRUSION
Saline Water Intrusion in Coastal aquifer: Occurrence of saline water intrusions, Ghyben-Herzberg relation, Shape of interface, control of seawater intrusion.
UNIT–IV: INTRODUCTION TO AIR QUALITY MODELING
Necessity, application and limitation of air quality modelling. Introduction to Dispersion Modeling, Photochemical Modeling and Receptor Modeling. Different air quality Dispersion models and their limitations.
UNIT –V: AIR QUALITY MODELS

Gaussian convection-diffusion model for point, line and areal sources. Introduction to commonly used Air quality models such as AERMOD, CALPUFF, CALINE4, ISCST3 models and CMAQ (CMAQ: The Community Multiscale Air Quality Modeling System). The Weather Research and Forecasting (WRF) Model.

Books Recommended

1. Air Quality Modeling: Theories, Methodologies, Computational Techniques, and Available Databases and Software, Anfossi. ISBN-10: 0-923204-56-3. Published in 2003.

2. Planning and managing regional air quality (Modeling and measurement studies): Solomon, P.A.Publisher : Lewis Publishers. Year 1994

3. An Introduction to Water Quality Modelling by James , 2nd Edition, published by Wiley. ISBN: 978-0-471-92347-3 December 1992.

4. Water Quality Modeling: Rivers, Streams, and Estuaries By R. Manivanan, New India publishing. ISBN9788189422936. Year of Publishing - 2008.

5. 5. Air pollution: measurement, modelling, and mitigation / Abhishek Tiwary and Jeremy Colls.—3rd ed. (2010)

Course Title	ENVIRONMENT HEALTH & SAFETY		
Course code	3ESTPE20	No. of credits	3
Center/ Department	Center for Environment , IST, JNTUH		
Program	M.Sc. : Environmental Science & Technology		
Course type	Program Elective III		
Course outcomes (COs)	**At the end of the course, the Student will be able to** **CO1: G**ive reasons for accident occurrence, how to investigate and report the accident and explain the responsibilities of safety officer. **CO2:** Explain about the industrial best work practices regarding machine guarding, occupational health, material handling and hazards storage practices etc. **CO3:** Give the causes for fire, describing the emergency preparedness and explain about prevention techniques of fire. **CO4:**Analyze the environmental stress in industries **CO5:** Explain the salient features of occupational safety management standards and Acts.		

UNIT I: INTRODUCTION TO SAFETY & HEALTH MANAGEMENT

Sequence of Accident Occurrence, Occupational Injuries-Effects of Industrial Accidents, Analysis of Accidents, Injury Data, Accident Investigations & Reporting, Accident Costing, Employer & Employee Responsibilities, Record-keeping & Reporting Requirements, Safety Organization, Responsibilities of Safety Officer, Supervisors, Safety committees.

UNIT II: WORK PRACTICES & BEST PRACTICES IN INDUSTRIES

Hazards in Chemical Operations, Material Handling Hazards, Lifting Machinery & Pressure Vessels, Material Safety Data Sheets, Classification of Chemicals, Hazardous Chemicals, Storage Practices, Radiation Safety, Petroleum Storage Requirements, Pesticide Safety, In Electrical, Mechanical, Fire, Machine Guarding, Personal Protective Equipment, Occupational Health, Ergonomics Ambulance, Noise Abatement Methods, Management Of Contractors.

UNIT III: FIRE SAFETY

Basic Elements, Causes, Industrial Fires, Explosions, Effect On Environment, Property & Human Loss, Prevention Techniques, Building Design, Fire Protection Systems, Contingency Plan, Emergency Preparedness, Evacuation.

UNIT IV: RISK MANAGEMENT&INDUSTRIAL HYGINE
Definitions of Hazards, Risks, Evolution of Methodical Analysis, System safety Analysis techniques, Performance measurement, Operational Reviews - Internal & External. **Environmental stresses**: physical, chemical, biological and ergonomic stresses, Principles of industrial hygiene, Overview of control measures. Permissible limits. Stress, Exposures to heat, Heat balance, Effects of heat stress, WBGT index measurement, Control Measures. Chemical agents, IS/UN classification, Flammables, Explosives, Water sensitive chemicals, Oxidants, Gases under pressure, Chemicals causing health hazards: irritants, asphyxiates, anaesthetics, systemic poisons and carcinogens, Chronic and acute exposure, Routes of entry, Types of airborne contaminants, Introduction to air sampling and evaluation methods, Occupational exposure limits, Engineering control measures, Principles of ventilation.
UNIT V: OCCUPATIONAL SAFETY MANAGEMENT STANDARDS & ACTS
Central Acts, Factory's Act, AP Factory Rules, Construction Safety Regulations, Petroleum Rules 2002, Electrical Act & Rules, Indian Standards, OHSAS 18001 Standard and its Elements, CE Certificate, Social Accountability Standards, System Implementation, Benefits.
Books Recommended 1. Industrial safety and health, David L. Goetsch, Macmillan Publishing Company, 1993. 2. Handbook of environmental health and safety, Vol I & II, Herman Kooren, MichaelBisesi, Jaico Publishing House, 1999. **Online resource:** 3. https://tsfactories.cgg.gov.in/home.do 4. https://labour.gov.in/list-enactments-ministry 5. https://www.osha.gov/laws-regs/regulations/

Course Title	CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT		
Course code	3ESTPE20	No. of credits	3
Center/ Department	Center for Environment , IST, JNTUH		
Program	M.Sc. : Environmental Science & Technology		
Course type	Program Elective III		
Course outcomes (COs)	**At the end of the course, the student will be able to** **CO1:** Categorise the role of aerosols and radiative effects of aerosols on global climate change. **CO2:** Elaborate changes in global climate and evaluate climate change policies **CO3:** Debate the impact of ecosystem, water resources developmental planning and their adaption on climate change. **CO4:** Infer GHG management, inorganic carbon sequestration on mitigation of climate change. **CO5:**Recommend climate modelling and early warning systems using GST towards Sustainable development in view of SDG's		

UNIT I: INTRODUCTION TO CLIMATE CHANGE

i. Introduction to atmospheres: vertical structure and residence time.
ii. overview of aerosols, radiative effects of aerosols: direct and indirect; scattering and absorbing behaviour of aerosols
iii. Energy budget - and greenhouse effect
iv. Global climate change- Evidences and Observations of climate change; Ice and climate change; Isotope evidence

UNIT II: CLIMATE CHANGE GOVERNANCE, INTERNATIONAL POLICY AND LEGAL FRAMEWORK

i. Global Climate Change Governance
ii. Climate change finance sources: Challenges and opportunities to accessing and managing climate finance
iii. Evaluate climate change policies:
   - UNFCCC and other entities
   - Kyoto protocol, Paris agreement
   - Climate negotiations
iv. National scenario: NAPCC, India's commitments (INDCs) and National Communication (NATCOM) initiative Policies and regulation: Important agencies and organizations.

UNIT III: CLIMATE CHANGE IMPACTS AND ADAPTATION

i. Climate Change Adaptation: Importance of adaptation- Adaptation options.
ii. Linkages between climate change adaptation and development planning
iii. approaches to climate change impacts and adaptation practices for:
   - ecosystems,
   - land use,
   - water resources and
   - human health
iv. Green Engineering

UNIT IV: CLIMATE CHANGE MITIGATION

i. Mitigation options :
   - technological and economic mitigation strategies:
ii. Biological and Inorganic Carbon Sequestration
iii. GHG Management
iv. energy system transformation and renewable energy technologies
v. carbon trading and carbon offsetting.
vi. Key sectors for low carbon development.
vii. The basic concepts of life cycle assessment (LCA) and Life cycle cost assessment (LCCA), common tools for performing LCA and LCCA.

UNIT V: CLIMATE CHANGE EARLY WARNING SYSTEM & SUSTAINABLE DEVELOPMENT

i. Climate Modelling: global and regional climate models, its applications and importance. Climate change projections.
ii. Climate Prediction and Early Warning System: Tools and Technologies
iii. Preparedness to Climate Change: Geospatial Approach
iv. Human Behaviour and Climate Change
v. Overview on SDG 2030:
vi. Sustainability: Need and concept, understanding sustainability and threats, Different types of tools for assessing sustainability in engineering.

References • Business and Climate – UNFCCC • GHG protocol – A Corporate Accounting and Reporting Standard • Kyoto Protocol – UNFCCC • Low carbon inclusive growth – GoI • Making Paris Work (Accepted Manuscript) • Fundamentals of Climate change • IPCC – Climate change Action, Trends and Implications for Business • India-Biennial report to UNFCC – 2015 • Global Warming – Six Indias • IPCC technical guidelines for assessing Climate change impacts and adaptation

TED talks • Can clouds buy us more time to solve climate change https://www.ted.com/talks/kate_marvel_can_clouds_buy_us_more_time_to_solve_climate_change • A critical look at Geoengineering against climate change - https://www.ted.com/talks/david_keith_s_surprising_ideas_on_climate_change • Let's prepare for our new climate(Adaptation) - https://www.ted.com/playlists/78/climate_change_oh_it_s_real

Documentaries • Before the flood (2016) • An inconvenient truth (2006) • National Geographic Six Degrees Could Change the World (2007) • An Inconvenient Sequel: Truth to Power (2017)

1. Handbook of climate change mitigation & Adaptation - Chen.Y
2. National acts for climate change – MoEF

Course Title	APPLIED GEOMATICS		
Course code	3ESTPE20	No. of credits	3
Center/ Department	Center for Environment , IST, JNTUH		
Program	M.Sc. : Environmental Science & Technology		
Course type	Program Elective III		
Course outcomes (COs)	**At the end of the course, The student will be able to** **CO1**Validate Air and space borne sensors with respect to spectral and radiometric resolutions. Appraise satellite navigation systems, outer space explorations, Chadrayan and Mangalyan. **CO2:** Formulate spectral information in estimation of vegetative indexes, precision agriculture, and crop and forest management. **CO3:** Illustrate role of remote sensing and GIS in Geological mapping, and identification of spectral signature on mining. **CO4:** Assess crop type classification and estimates, watershed impact on soil erosion and water quality modeling. **CO5:** Analyze spectral response on upland and wetland vegetation ecosystem, urban and municipal solid waste studies.		

UNIT I: SENSORS AND SATELLITES

i. **SENSORS AND PLATFORMS**

i. Introduction, satellite system parameters- instrumental and Viewing, Sensors- Active and passive, classification, sensor parameters- spatial, spectral and radiometric resolutions

ii. Platforms- Airborne and Space borne, constraints of satellite geometry, effects of the local environment, common orbits and details of elevation angle and ground area, types of Scanners

SATELLITE PROGRAM'S

i. INSAT series, IRS series, RADAR imaging satellites, other satellites, GAGAN & IRNSS satellite navigation system

ii. Extra-terrestrial exploration- chandrayaan-1 and 2 & Mangalayaan, International cooperation of ISRO, future projects of ISRO

UNIT II: SPECTRAL INFORMATION FOR SENSING VEGETATION & APPLICATIONS

SPECTRAL INFORMATION FOR SENSING VEGETATION

i. Estimation of Vegetation Cove: Spectral Indices -Vegetation indices and vegetation descriptors.

ii. Microwave vegetation indices- estimation of vegetation using Lidar.

INTEGRATED APPLICATIONS

i. Detection and diagnosis of plant stress.

ii. Precision agriculture and crop management

iii. Ecosystems and Forestry Management.

UNIT III: SOIL SCIENCES

i. Role of Remote sensing and GIS in geological studies and case studies. Evaluation of Geological Mapping
ii. Introduction to Prospection Techniques, History of Remote Sensing in Geological Exploration. Image Lineaments and structural origin, Prospecting, Applications of thermal and Radar remote sensing in structural geology.
iii. Spectral response of Minerals, Rocks, Alterites, case studies

UNIT IV: WATER RESOURCES, AGRICULTURE AND FORESTRY

i. The hydrological cycle, Hill slope hydrology, the drainage basin, Channel networks, Automatic derivation of catchment characteristics, the global cycle. Ground water exploration and targeting. Introduction, Characteristics, Watershed and people, Watershed characteristics, watershed management and Integrated approach for sustainable planning. Water quality modeling. Watershed Management in India, Case studies.
ii. Soil and altitude, Soil and aspect, Soil and slopes, Soil landscapes, Soil erosion modeling.
iii. Crop type classification, area estimates, and spectral response of different crops. Crop diseases and Assessment, Crop and Water management and monitoring. Advances in Crop monitoring.

UNIT V: RESPONSE OF ECOLOGICAL FACTORS AND IMPACT STUDIES, MODELLING

i. Spectral response of vegetation and mapping, Ecosystem Analysis, Environmental impact analysis and monitoring, Ecosystem modeling,
ii. Wetland mapping.
iii. Urban growth studies
iv. Municipal solid waste studies
v. Land use land cover change detection studies
vi. Spatial Models of Ecological Systems and Process

Books Recommended

1. M.Anji Reddy, Text book of Remote sensing and GIS by, BSP Publications, Hyderabad, 2001.
2. Principles of Remote sensing, An introductory Text book by the international institute for Geo-Information sciences and Earth Observation (ITC).
3. Satellite Technology: Principles and Applications, 2nd Edition, Anil K. Maini, Varsha Agrawal, ISBN: 978-1-119-95727-0694 pages, June 2011.

Course Title	WASTE TO ENERGY		
Course code	3ESTOE21	No. of credits	03
Center/ Department	Center for Environment , IST, JNTUH		
Program	M.Sc. : Environmental Science & Technology		
Course type	Open Elective-III		
Course outcomes (COs)	**At the end of the course, the Student will be able to** **CO1:** Classify the wastes as a fuel. **CO2:** Understand types of pyrolysis. **CO3:** Differentiate types of Biomass Gasification. **CO4:** Understand the Biomass Combustion processes. **CO5:** Analyze the biogas plant design and types of biogas plants.		

UNIT I: INTRODUCTION TO ENERGY FROM WASTE
Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digesters.
UNIT II: BIOMASS PYROLYSIS
Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application
– Manufacture of pyrolytic oils and gases, yields and applications.
UNIT III: BIOMASS GASIFICATION
Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.
UNIT IV: BIOMASS COMBUSTION
Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

UNIT V: BIOGAS: PROPERTIES OF BIOGAS (CALORIFIC VALUE AND COMPOSITION)
Biogas plant technology and status - Bioenergy system - Design and constructional features - Biomass resources and their classification – Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications – Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.
Books Recommended 1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990. 2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata 3. McGraw Hill Publishing Co. Ltd., 1983. **Reference Text Books:** 4. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991. 5. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

Course Title	**ENERGY AUDIT**		
Course code	**3ESTOE21**	No. of credits	3
Center/ Department	Center for Environment , IST, JNTUH		
Program	M.Sc. : Environmental Science & Technology		
Course type	**Open Elective-III**		
Course outcomes (COs)	**At the end of the course, the Student will be able to** **CO1**: Demonstrate the types of energy and their production, consumption and Future strategies of energy role in climate change. **CO2**: Examine the Basics of electricity and its demand along with thermal energy production and effects. **CO3**: Estimate the energy audit practices along with Energy consumption reducing appliances and their efficiency like CFL & LED **CO4**: Assess the energy systems and process flow. Explain the energy monitoring and targeting. **CO5**: Evaluate the energy management systems, designing, marketing strategies.		

UNIT I: ENERGY SCENARIO

Commercial and Non-Commercial Energy, Primary Energy Resources, Commercial Energy Production, Final Energy Consumption, Energy Needs of Growing Economy, Long Term Energy Scenario, Energy Pricing, Energy Sector Reforms, Energy and Environment: Air Pollution, Climate Change, Energy Security, Energy Conservation and its Importance, Energy Strategy for the Future, Energy Conservation Act-2001 and its Features.

UNIT II: BASICS OF ENERGY AND ITS VARIOUS FORMS

Global Climate Change Governance. Electricity basics - DC & AC currents, Electricity tariff, Load management and Maximum demand control, Power factor. Thermal basics -Fuels, Thermal energy contents of fuel, Temperature & Pressure, Heat Capacity, Sensible and Latent heat, Evaporation, Condensation, Steam, Moist air and Humidity & Heat transfer, Units and conversion.

UNIT III: ENERGY MANAGEMENT & AUDIT
Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Benchmarking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Light Emitting Diode (LED) and Compact Fluorescent Lights (CFL), Fuel and energy substitution, Energy audit instruments
UNIT IV: MATERIAL AND ENERGY BALANCE
Facility as an energy system, Methods for preparing process flow, Material and energy balance diagrams. Energy Monitoring and Targeting: Defining monitoring & targeting, Elements of monitoring & targeting, Data and information analysis techniques, energy consumption, Production, Cumulative sum of differences (CUSUM)
UNIT V: ENERGY ACTION PLANNING
key elements, force field analysis, energy policy purpose, perspective, contents, formulation, ratification, organizing- location of energy management, top management support, managerial functions, roles and responsibilities of energy manager, accountability, motivating-motivation of employees, information systems- designing barriers, strategies, marketing and communicating-training, and planning - Financial Management
Books Recommended: 1. Energy management handbook by Wayne C. Turner & Steve Doty. 6th ed. (2006). 2. Energy Management Principles, C.B.Smith, Pergamon Press. (2013) **Online resources:** 1. NCE for Energy Managers & Energy Auditors website. http://aipnpc.org/

Course Title	GREEN BUILT ENVIRONMENT		
Course code	3ESTOE21	No. of credits	3
Center/ Department	Center for Environment , IST, JNTUH		
Program	M.Sc. : Environmental Science & Technology		
Course type	Open Elective III		
Course Program outcomes (COs)	**At the end of the course, the student will be able to** **CO1:** Identify the sustainable/green building methods, materials and tools **CO2:** Classify relevance of site selection, ecology, climate and soil for building construction. **CO3:** Compose recyclable models and modern irrigation practices for environmental modeling. Discuss sustainability of Land management, Net farm profitability, and Principles of ecology for planners. **CO4:** Summarize the need of energy management practices. **CO5:** Examine the indoor environmental quality issues.		

UNIT I: INTRODUCTION & SUSTAINABLE BUILDING MATERIALS

Sustainable Building overview, Social and Economic issues, The Science of Sustainable Neighborhoods, Materials, Products and systems for sustainable buildings, Sustainable retrofit of buildings, Methods and tools, Neighborhood sustainability performance, Integrated research project, Green city / Building rating indicators;

Attributes of Sustainable Building Materials: Recycled content, Regional material, Renewable material, Embodied energy, Embodied carbon, Material performance, Recyclability, Elimination of hazardous materials; Ecolabeling of Products: Types of Ecolabels – Type I, II & III ; Sustainable Materials for Green Buildings

UNIT II: SUSTAINABLE ARCHITECTURE & SITES

Integrated Approach for Green Building design: Factors for Site selection, Understanding Site Ecology & Site Analysis; Soil erosion & pollution control measures: types of Soil Erosion, strategies to Mitigate Land Degradation, Design Techniques & Challenges; Microclimate: Factors affecting microclimate heat Islands, Strategies to handle heat island in built environment, Designing Green Spaces and Enhancing Biodiversity in built environment; Universal Design: Key accessibility issues and Design guidelines.

UNIT III: WATER & WASTE MANAGEMENT
Water Balance and approach for water efficiency: 3R Approach for water efficiency – Reduce, Reuse/ Recycle and Recharge; Water efficient plumbing fixtures, Standards& Codes; Efficient irrigation practices – Hydro zoning, Control devices for water supply, Irrigation systems – Drip & Sprinklers; Wastewater treatment & reuse, wastewater treatment technologies: Physical, Biological and Natural; Rainwater harvesting and utilization, Groundwater recharge techniques: Design considerations; Waste management during construction & post-occupancy: Segregation strategies, Types of waste management – organic, inorganic, e-waste, hazardous waste.
UNIT IV: ENERGY MANAGEMENT
Introduction, Performance Evaluation and Approach for Energy Efficiency in Buildings; Energy Efficiency Standards & Codes: ECBC 2017 & EPI, ASHRAE 90.1, ASHRAE 62.1, ASHRAE 55, ASHARE 170, ISHRAE 1001, Star labeling for appliances; Efficient Building Envelope: Heating loads in buildings, Building orientation and form, Envelope Heat Transfer & Material Specifications – Wall, Roof & Fenestration; Air Conditioning: Types of air conditioning systems, Design Considerations and control systems; Lighting in Building: Day lighting & Artificial Lighting, Methods to determine ECBC compliance for interior lighting and Lighting Controls; Renewable Energy systems and technologies
UNIT V: INDOOR ENVIRONMENTAL QUALITY
Indoor Air quality: Codes and Standards, Fresh air requirements, Design considerations; Approach for improving Indoor air quality: Measures to reduce sick building syndrome, Demand control ventilation, CO2 monitoring in buildings, Air quality monitoring; Enhancing occupants' Comfort, Health and Wellbeing: Thermal Comfort, Visual Comfort, Acoustics, Ergonomics, Olfactory Comfort.
Books Recommended 1. Indian Green Building Council (IGBC) Annual Review : 2016 – 2017, Oct 20, 2017 [Book/Printed Report] 2. Green Buildings of India: The Pioneers who has changed the Perspectives. Oct 06, 2016 3. IGBC Green Factory Building Rating System- Abridged Reference Guide. Dec 15, 2010 4. Indian Green Building Council (IGBC) Annual Review : 2016 – 2017. Oct 20, 2017 **Online resources:** 1. https://performancechallenge.igbc.in/

Course Title	**PROKARYOTIC DIVERSITY AND BIO-PROSPECTING (Tiny Earth course of USA)**		
Course code	**3ESTOE21**	No. of credits	03
Center/ Department	Center for Environment , IST, JNTUH		
Program	M.Sc.. : Environmental Science & Technology		
Course type	**Open Elective-III**		
Program Educational Objectives(PEOs)	**At the end of the course, the Student will be able to:** **CO1:** Students will be exposed to the basic and applied science of microorganisms in their environment. **CO2:** Develop an understanding of and learn about prokaryotic diversity and discovery of novel antimicrobial compounds from them through hands on experience involving research. **CO3:** Gain knowledge and training in diverse isolation techniques for prokaryotes including the new approaches. **CO4:** Provide knowledge and hands on experience on screening techniques for the production of antimicrobial compounds.		

UNIT I: ISOLATION AND PURIFICATION OF MICROORGANISMS: CONVENTIONAL METHODS.

Media preparation and various types of media, Sterilization, Inoculation- different inoculation devices, Incubation, Isolation and purification using Streak plate, Spread Plate and Pour plate, Cultivation of microorganisms –Plate cultures, Stroke cultures, stab cultures, roll tube culture, Shake culture etc , use of diverse media and culture conditions, Preservation of microorganisms

UNIT II: ISOLATION AND PURIFICATION OF MICROORGANISMS: NEW APPROACHES.

Great plate count anamoly & enrichment bias. Specific methods devised for isolating uncultured microorganisms in pure culture, community culture and coculture, high through put methods e.g. diffusion chambers, I chip, microbial trap, micropipette holder plate, use of optical tweezers, high throughput micro bioreactor single cell isolation, use of genomic information and preparation of smart media etc. .

UNIT III: CHARACTERIZATION, IDENTIFICATION AND DESCRIPTION OF NEW TAXA OF PROKARYOTES

Polyphasic characterization: Ecological, cultural, morphological, physiological, biochemical and genetic characterization. Taxogenomics, Diagnostic features. Bacterial nomenclature, etimology in nomenclature of prokaryotes. Bacteriological code, valid and effective publication of description of new taxa.

UNIT IV: SCREENING FOR ANTIMICROBIAL ACTIVITY

Sample collection, Dilution plating of soil sample, Solid versus liquid culture, Picking and Patching Colonies, Choosing ESKAPE Pathogens, Screening for isolate with antibiotics production- Patch/Patch, Spread/Patch, Top Agar, Identification and characterization of

antibiotic producing isolates

UNIT V: SEPARATION, ISOLATION AND IDENTIFICATION OF ANTIMICROBIAL COMPOUNDS.

Organic molecules, secondary metabolites, Extraction of secondary metabolites, extraction using organic solvents, chromatographic methods, Assessing the antibiotic resistance of isolates, Biochemical characterization of organic molecules

Books Recommended

1. Bergey's manual of systematic bacteriology.
2. Review articles. From:
   a) Annual Review of microbiology
   b) Adv. Microbial physiol.
   c) FEMS microbial reviews.
   d) Bacterial reviews.
   e) Int. J. Systematic and Evolutionary microbiology.
3. The Prokaryotes. 7 volumes. Springer's, New York.
4. The prokaryotes. An evolving electronic resource for the Microbiological community. – Springer – Verlag, New York.
5. The latest edition of Tiny Earth: A Research Guide to Student sourcing Antibiotic Discovery and Tiny Earth: Instructor Guide

Course Title	**WASTEWATER TREATMENT LAB**		
Course code	**3ESTL22**	No. of credits	03
Center/ Department	Center for Environment , IST, JNTUH		
Program	M.Sc. : Environmental Science and Technology		
Course type	**Laboratory - V**		
Course outcomes (COs)	**At the end of the course, the Student will be able to** **CO1:** Demonstrate different physico, chemical and biological treatment techniques **CO2:** Choose appropriate tailor made treatment techniques for different effluent streams **CO3:** Experiment to find suitable low cost treatment scheme **CO4:** Think on cost economics for wastewater treatment. **CO5:** Choose the treatment method for ZLD system and also for recovery of materials		

Water and waste water treatment methods

1. Coagulation
2. Softening
3. Mixing and Flocculation
4. Chlorinating and Disinfection
5. Defluoridation
6. Hardness removal by lime soda process
7. Reverse Osmosis

Unit operations for wastewater treatment

1. Trickling filter
2. Activated Sludge
3. Rotating biological contactor
4. Anaerobic digester
5. UASB
6. Adsorption
7. Ion exchange

Course Title	**ENVIRONMENTAL MODELING LAB**		
Course code	**3ESTL23**	No. of credits	03
Center/ Department	Center for Environment , IST, JNTUH		
Program	M.Sc. : Environmental Science and Technology		
Course type	**Laboratory -VI**		
Course outcomes (COs)	**At the end of the course, the Student will be able to** CO1: Demonstrate the use of open source software for Groundwater modeling. CO2: Demonstrate the use of open source software for Air Quality modeling. CO3: Perform statistical analysis including central tendencies, deviation and variance for given data. CO4: Compare observed data with hypothesis using test of significance methods. CO4: Assess Correlation and Regression between two or more variables.		

Environmental Modeling:

Groundwater Modeling - Open source Software

Air quality Modeling - Open source software.

Statistics

1. Determination of Central tendencies.
   a) Mean b) Median c) Mode
2. Determination of Geometric mean & harmonic mean.
3. Determination of measures of dispersion
   a) Mean deviation b) Standard deviation and coefficient of variation
4. Test of Significance- Application of following.
   a) Chi-Square test b) t-test c) standard error
5. Analysis of Variance (ANOVA)
   a) One way b) Two way
6) Correlation and Regression

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