M. Tech. Energy & Environment (Regular)

Year 2019-2021

Syllabus

School of Energy & Environmental Studies

Devi Ahilya Vishwavidyalaya,

Takshashila Campus, Khandwa Road,

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M.TECH. (Energy & Environment Management)
2019-2021

M Tech Energy & Environment Management

Eligibility At least 55% aggregate marks in B.E. / B. Tech. in any branch of Engineering or Masters Degree in Energy, Physics, Chemistry, Environment Science, and Environment Engineering.

Duration Four Semesters (Two Years).

Seats **25;** Reservation for SC/ ST/OBC as per MP Government Rule

First Semester:

Code	Title	Credits (L+T+P)	Hours	Faculty
CORE COURSES				
EN7B-701	Solar Energy Systems and Technologies	4 (3+1+0)	64	SPS
EN7B-702	Wind Energy Science and Technologies	4 (3+1+0)	64	RNS
EN7B-703	Water & Waste Water Treatment Technologies	4 (3+1+0)	64	RC
EN7B-704	Modeling of Energy & Environment Systems	4 (3+1+0)	48	DS
EN7B-705	Energy Laboratory	3 (0+0+3)	64	RNS
EN7B-706	Seminar	1(0+0+1)	16	SPS/RNS/RC
ELECTIVE COURSES				
EN7B-707	Energy & Environment Nano Technologies	3 (2+1+0)	48	RC
EN7B-708	Comprehensive Viva-Voce	4		
	Total Credit	27		

Second Semester:

Code	Title	Credits (L+T+P)	Hours	Faculty
CORE COURSES				
EN7B-709	Energy Management	4 (3+1+0)	64	SPS
EN7B-710	Air and Noise Pollution Control Engineering	4 (3+1+0)	64	RC
EN7B-711	Bio-fuel Technology	4 (3+1+0)	64	RNS
EN7B-712	Environmental Laboratory	3 (0-0-3)	48	RC
EN7B-713	Mini Project in Environment	4 (0+0+4)	64	SPS/RNS/RC
ELECTIVE COURSES				
EN7B-714	Heat & Mass Transfer	3 (2+1+0)	48	DV
EN7B-715	Comprehensive Viva-Voce	4		
	Total Credit	26		

Third Semester:

Code	Title	Credits (L+T+P)	Hours	Faculty
CORE COURSES				
EN7B-801	Green Building Design & Simulation	4 (3+1+0)	64	SPS
EN7B-802	Solid and Hazardous Waste Management	4 (3+1+0)	64	RNS
EN7B-803	Unit Operation & Unit Process in Environmental Technology	4 (3+1+0)	64	RC
EN7B-804	Energy and Environmental Audit & Impact Assessment	4 (3+1+0)	64	DS
EN7B-805	Mini Project in Energy	4 (0+0+4)	64	SPS/RNS/RC
ELECTIVE COURSES				
EN7B-806	Economics of Energy and Environment Systems	3 (2+1+0)	46	VF
EN7B-807	Comprehensive Viva-Voce	4		
	Total Credit	27		

Fourth Semester:

Code	Title	Credits (L+T+P)	Hours	Faculty
CORE COURSES				SPS/RNS/RC
EN7B-808	Major Project	12 (0-0-12)	192	
EN7B-809	Comprehensive Viva-Voce	4		
	Total Credit	16		

EN7B- 701: Solar Energy Systems and Technologies

Credits: 4 (64 Hours)

UNIT I: Earth & Sun Relationship

Earth & Sun Relation: Solar Angles, Day length, Angle of Incidence on Tilted Surface, Sun path Diagram, Shadow determination.

Available Solar Radiation: Extraterrestrial Characteristics, Effect of Earth Atmosphere, Measurement and Estimation on Horizontal and Tilted Surface.

Solar Radiations Characteristics Coating: Transparent and Opaque Materials, Selective

UNIT II: Solar Collectors

Flat Plate Collectors: Effective Energy Losses, Thermal Analysis, Heat Capacity Effect, Evacuated Tubular Collectors.

Flat Plate Air Collectors: Types, Thermal Analysis

Concentrating Collectors: Designing and types, Thermal Analysis, Single Axis and Two Axis Solar Tracking.

Evacuated Tubular Collectors: Types, Thermal Analysis

Solar Cookers: Types, Thermal Analysis, and Testing Methods

UNIT III: Thermal Energy Systems & storage

Thermal Energy Storage: Sensible Storage (Water, pebble bed and ground storage) Latent Heat Storage, Solar Water Heating System: Components, Natural Flow, Forced Flow & Load Estimation Gravity Flow Systems, Mathematical Modeling.

Solar Air Heating Systems: Space Heating, Solar Drying, Load Estimation

Solar desalination system: Design and type, Solar still, performance analysis

UNIT IV: Solar Refrigeration and Desiccant

Cooling: Vapor Absorption Refrigeration cycle, Water ammonia and Lithium bromide – water absorption refrigeration systems, Solar Operated Refrigeration Systems, Solar Desiccant cooling (4-1/2).

UNIT V: Solar Power Generator

Solar Thermal Power Generation: Basic Operating and applications, Parabolic trough Systems, Parboloidal Dish Systems, Heliostat system, Central Receiver Power Plants, Solar Furnace

Solar Photovoltaic System: Basic Semiconductor Theory, Photovoltaic Principles, and Solar Cells: Characteristics, Types and Production Methods, Series parallel combination, Storage Batteries, Modules

Stand Alone, Grid Connected Hybrid System, DV Arrays, Energy Storage Devices, Power Conditioning, DC Bus Voltage, Power Distribution Devices and Guidelines

Solar Pond: Working principles & System, Application

Recommended Books:

1. Duffle and Beckman, Solar Thermal Engineering Process, John Wiley & Sons, New York
2. J.S. Hsieh, Solar Energy, Prentice Hall Inc. New Jerssey
3. A.B. Meinel and M.B. Meinel, Applied Solar Energy, Addison – Wiley Pub. Co., Reading
4. P.J. Lunde, Solar Thermal Engineering, John Wiley & Sons, New York

5. N.C. Harris, C.E. Miller and I.E. Thomas, Solar Energy Systems Design, John Wiley & Sons, New York
6. H.P. Garg, Advanced in Solar Energy Technology, D. Reidel Publishing Co., Drdricht.
7. S.P. Sukhatme, Solar Energy, Tata McGrew Hill Company Ltd., New Delhi
8. M.A. Greaen "Solar Cells – Operating Principles, Technology, and System Applications", 1983 Prentice Hall, Inc. New Jersey.
9. Markvart, Solar Electricity, John Wiley
10. F. Kreith and J.F. Kreider, Principles of Solar Engineering Hemisphere Publishing Coro.
11. G.N. Tiwari and S. Suneja, Solar Thermal Engineering Systems, Narosa Publishing House.
12. Goden – Solar Energy
13. M P Agrarwal - Solar Energy
14. W H Blass, F. Pfisterer – Advance in Solar Energy Technology
15. Mathur and Methaf - Solar Energy

EN7B- 702: Wind Energy Science and Technologies

Credits: 4 (64 Hours)

Unit-I: Indian & World Wind Energy Scenario

Contribution of wind power in Renewable Energy In India and world, scenario of wind power in India and world, Countries which are blessed by wind power, contribution of wind power in total power requirement of developed and developing country including India, Future Scenario of wind power in India and world

Unit-II: Wind Recourses

Nature of the wind, Variation in the wind recourses, Turbulence in wind velocity, extreme wind speed, wind speed prediction and forecasting, Basic principle of wind energy Conservation, characteristics of wind power, Extractable wind power, Site selection, wind data analysis and predictions, anemometry, wind statistics; speed frequency distribution, effect of height, wind rose, Weibull distribution, atmospheric turbulence, gust wind speed, effect of topography.

Unit-III Wind Energy Turbine

Wind Energy Conversion principles; Types and classification of Wind Energy Conversion system; Horizontal axis Wind Energy Turbine, Vertical Axis Wind Energy Turbine, Power, torque and speed characteristics, Aerodynamic construction of rotor blades, Actuator disc concept, Rotor disc theory, rotor blade theory, wind Farms, wind mills & their applications Electricity generating by stand-alone systems & grid connected systems.

Unit-IV Performance of Wind Energy Turbine

Wind Rose Diagram, Effect of Blade angles on the performance of wind turbine, Performance of horizontal axis wind turbine, Wind turbine design considerations; Methodology; Theoretical simulation of wind turbine characteristics; Optimal blade design for variable speed operation,

Optimal blade design for constant speed operation, effect of drag force on performance of vertical axis wind turbine, Performance of wind water pumping system

Unit-V: Wind hybrid system & New Development in Wind Turbines

Wind hybrid system: Ccontrol mechanism, Grid Connection of Wind hybrid system, advantage and disadvantage of hybrid system,

Airborne Wind Turbines: Definition, working principle of Airborne Wind Turbines, types of Airborne Wind Turbines, power transmission mechanism in Airborne Wind Turbines, advantage and disadvantage of Airborne Wind Turbines.

Wind Stalk: Definition, working principle of wind stalk, types of wind stalk, power transmission mechanism in wind stalk

Recommended Books

1. Twidell & AW. Wier, Renewable Energy Resources, English Language book, Society *I* E & FN Spon (1986).
2. V.D., Hunt, Wind power: A handbook on Wind energy Conversion systems. Van Nostrand Reinhold Company, 1981.
3. Tony Burton, David Sharpe, Nick Jenkins and Ervin Bossanyi (2001)Wind Energy handbook, Published by John Wiley & Sons.
4. Paul Gipe1995**,** Wind Energy Comes of Age,Published by **Inc New York** John Wiley & sons, New York.
5. Earnest, Joshua, Wind Power Technology, Earnest economy Second Edition
6. Tony Burton, DavidSharpe, Nick Jenkins and Ervin Bossanyi, 2001, Wind Energy Handbook, Published by John Wiley & sons, Ltd.
7. N.K. Bansal., M. Kleeman & M. Mielee, Renewable conversion technology, Tata McGraw Hill, New Delhi.
8. Kreith Goswami – Hand Book of Energy Efficiency and Renewable Energy
9. TERI Energy Data Year Books.
10. Planning commission statistics
11. www.bp.com/centres/energy
12. www.eia.doe.gov
13. www.epa.org
14. Bureau of Energy Efficiency- Volume 1

EN7B -703: Water & Waste Water Treatment Technologies

Credits: 4 (64 Hours)

UNIT I

Fundamentals: Definition, Classification, Sources, Water quality Standards.

Water Chemistry: Theory of Acid Base Equilibrium, Water Pollution And Control: Indicators, Hardness & Determination of DO BOD, COD of Water, and Water Pollution due to heavy metals and Organic Pollutants.

Surface Water Treatment: Water Purification, Processes in Natural Systems (Physical, Chemical, Bio-Chemical Processes) and Its Application, Response of Stream to Bio-Degradable Organic Wastes.

UNIT II

Water Treatment Methods: Principles and Design, Aeration Systems, types of settling and settling equations, design criteria and design of settling tanks.

Coagulation and Flocculation – types of coagulants, coagulant aids, coagulation theory, optimum dose of coagulant, jar test method, design criteria and numerical examples.

Filtration – theory, types, filter backwash, operational problems and trouble shooting.

UNIT III

Unit processes, Water Softening- Principles and design- Ions causing hardness, various methods.

Waste Water Treatment: Principles and Design, Objectives of wastewater treatment, characteristics, flow variations, types of reactors and reactors analysis. Mass Loading Factors, Impacts, Estimation and Their Unit Loading.

UNIT IV

'Principle of Biological Treatment; Microbial Growth Rates, Treatment Kinetics, Food/Micro Organism Ratio, Substrate Removal Efficiency.

Theoretical principles and design : Aerobic Suspended Growth Systems, Activated Sludge, Aerated Lagoon, Principles and design of stabilization ponds, Aerobic Attached Growth, Trickling Filters,

UNIT V

Anaerobic - UASBS, Sludge Digesters, Anaerobic Ponds. Different Types of Industrial Effluent Treatment Plants.

Sludge Processing: separation - sludge thickeners, volume reduction, conditioning and digestion – aerobic and anaerobic. Numerical problems and Case Studies

References

1) Environmental Pollution and Its Control Jeffrey J. and P.A. Vesilind.
2) Chemistry for Environmental Engineering Clair N. Sawyer & McCarty, TATA McGraw Hill International Publication IIIrd Edition.1986
3) Environmental Engineering - Howard S. Peavy et.al, TATA McGraw Hill International Publication 1st Edition. 1986
4) Environmental Engineering – Ruth F. Weiner and Robin Matthews fourth edition.
5) Water & Waste Water Technology - Marle J. Hammer, Prentice Hall of India Ltd. New Delhi 2nd
6) Waste Water Treatment, Disposal & Reuse - Metcalf & Eddy, TATA McGraw Hill Publication New Delhi 3rd Edition.
7) Waste Water Treatment for Pollution Control – Soli J. Arceivala, TATA McGraw Hill Publication New Delhi 2nd Edition.
8) Energy Conservation in water and wastewater facilities.
9) Water Treatment Handbook, Vol. 1& 2
10) "Manual on water supply and Treatment ", CPHEEO, Ministry of Urban Development, GOI, New Delhi, 1999.

EN7B-704: Modeling of Energy & Environment Systems

Credits: 4 (64 hours)

UNIT I Basic concepts in ecology and ecological modeling, Population Dynamics: Birth and death processes. Single species growth, Prey-predator models: Lotka-Volterra, Rosenzweig Mac Arther, Kolmogorov models. Multi-species modeling, Primary production, primary and secondary consumers, Structural analysis and stability of complex ecosystems.

UNIT II Continuous-Flow Reactor Modeling: CSTR, Plug-Flow, Dispersion. A case study of a tubular reactor with axial dispersion, Parameter Calibration: Search algorithms for nonlinear dynamical models, Variance of estimated parameters. Application to Monod and Haldane kinetics.

UNIT III
Basic mechanisms of river self-purification, Streeter-Phelps and Dobins models. More complex chemical and ecological models. Pollutant and nutrient dynamics. Dissolved Oxygen dynamics.

UNIT IV
Fundamentals of microbial dynamics and energetics. Pollutant/Microorganisms interactions, Requirements for carbon and nutrient removal. Activated sludge: Process schemes: completely mixed, plug-flow, SBR, nutrient removal. Anaerobic digestion: process dynamics, Operational control of wastewater treatment processes.

UNIT V Fuzzy System Modeling Introduction to fuzzy sets and systems, fuzzification, implication, connectives, defuzzification, rule-based fuzzy models with different approaches (Mamdani and Sugeno). Cluster analysis for the classification of ecological data,. Integration between fuzzy clustering and fuzzy models.

REFERENCES
1. Arthur C.Stern., Air Pollution (Third Ed.) Volume I – Air Pollutants, their transformation and Transport, (Ed.), Academic Press, 2006.
2. Chapra, S.C. Surface Water-Quality Modeling, McGraw-Hill, 2008.
3. Deaton, M.L and Winebrake, J.J., Dynamic Modeling of Environmental Systems, Verlag, 2000.
4. Orhon, D and Artan, N., Modeling of Activated Sludge Systems, Technomic Publ. Co., 1994.
5. Schnoor, J.L., Environmental Modeling Fate and Transport of Pollutants in Water, Air and Soil, John Wiley & Sons Inc., New York, 1996.

EN7B- 705: Energy Laboratory

Credits: 3 (48 hours)

1) Thermal Performance of a Solar Flat Plate Collector.
2) Thermal – Performance of Box Type and Concentrator type Solar Cookers.
3) Determination of Load Characteristic of a Solar PV Module.
4) Measurement of Global and Diffuse Irradiance.
5) Thermal Performance of a Solar Still.

6) Determination of Proximate and Ultimate analysis of biomass
7) Determination of Calorific Value of solid and liquid fuel
8) Heat Transfer in an Air to Water Finned Heat Exchanger.
9) Stack Analysis: ORSAT Apparatus.
10) To Study the Composition yield of Methane from Different Feed Stocks.
11) To estimate the energy content of gaseous fuel using Junker Gas Calorimeter
12) To estimate the exhaust gas composition using the Orsat apparatus
13) Preparation of bio-diesel and determination of it physical properties
14) Determination of Fats/oil Content in a given oil seed Biomass Sample
15) Calibration of thermocouples
16) Characteristics (Viscosity, density, fire point, flash point, cloud point & pour point) of Vegetable oil

EN7B- 706: Seminar

Credits: 1 (16 hours)

In this course, students suppose to collect the latest information/development on the new technologies/System/ Methods related to Energy and Environment. Prepare the report, submit it to the Examination in charge and present it (through PPT) in front of the Examiner (s).

EN7B-707: Energy & Environmental Nano Technology

Credits: 3 (48 hours)

Unit-I: Synthesis and Advanced Characterization of Nano-materials

Physical and chemical method of synthesis for SWCNT, MWCNT, Metal nanoparticles and Metal oxide and Chalcogenide nanoparticles. Biologically Synthesized Nanoparticles, Nanostructures and Synthetic Nano-composites - Protein-Based Nanostructure Formation – DNA Templated Nanostructure Formation - Protein Assembly - Biologically Inspired Nano-composites

Unit-II: Properties of Nano-material

Carbon nanotubes: electrical properties, vibrational properties, mechanical properties and applications of carbon nanotubes: field emission and shielding, computers, fuel cells, chemical sensors, catalysis – mechanical reinforcement. Semiconductor nanostructures – electronic properties, optical behavior and quantum confinement, characterization of semiconductor nanostructures.

Unit-III: Nano-materials in Environment DNA

Protein, molecular motors, aerosols, self-assembly and natural surfactants, Identification and characterization of Hazardous waste, Nano Pollution, Air, Water and Soil Contaminants. Environmental Nano Remediation Technology - Nanotechnology for water remediation and

purification: nZVI, Ag, Photofenton process, TiO_2 and its modification for efficient photodegradation, Nano Filtration for treatment of waste – removal of organics & inorganic and 44 pathogens, Nanomembranes in Drinking water treatment, Nanomembranes in Sea desalination. Application of Nanomaterial in micro fuel cell, fuel Cell, hydrogen storage.

Unit-IV: Environmental Nanotoxicology

Fate of nanomaterials in environment, environmental life cycle of nano materials, environmental and health impacts of nano materials, toxicological threats, eco-toxicology, exposure to nano particles – biological damage, threat posed by nano materials to humans, environmental reconnaissance and surveillance.

Unit V Environmental Applications

Gas sensors, microfludics and lab on chip, catalytic and photocatalyic applications, Nonmaterials for ground water remediation, nanomaterials as adsorbents, membrane process, Energy applications-H_2 storage.

References:

1. Balaji S., (2010). Nanobiotechnology, MJP Publishers,Chennai.
2. Poole, C. P. Jr. and Owens F. J. (2009). Introduction to nanotechnology, Wiley India, New Delhi.

EN7B-708: Comprehensive Viva-Voce

Credits: 4 (64 hours)

Comprehensive Viva-Voce: At the end of the semester student (s) knowledge gain during the semester would be evaluated orally by panel of 04 Examiner, which include 01 External and 3 internal Examiner.

EN7B -709: Energy Management

Credits: 4 (64 Hours)

UNIT I

Fuel Analysis: Proximate Analysis, Ultimate Analysis, Calorific Value. Combustion: Theoretical Air Requirement, Efficiency Estimates, Combustion Control, Stability in Flames.

Furnaces**:** Classification, Excess Air and Heat Distribution Losses, Temperature Control, Draft Control.

Insulation and Refractory: Insulation Type and Application, Refractory-Types, Selection and Application of Refractory,

UNIT II

Boilers: Types, Analysis of Losses, Performance Evaluation, Feed Water Treatment, Blow Down, Energy Conservation Opportunities, AFBC, CFBC, PFBC Boilers, Condensing Boilers, Saving Potential,.

Steam System: Properties of Steam, Assessment of Steam Distribution Losses, Steam Leakages, Steam Trapping, Condensate and Flash Steam Recovery System,

Cogeneration: Need, Applications, Advantages, Topping Cycles, Bottoming Cycles, Combined Cycles, Steam Tracking Mode, Electricity Tracking Mode, Saving Potential, Case Studies.

UNIT III

Waste Heat Recovery: Commercially Viable Heat Recovery Devices, Saving Potential, Case Studies, HVAC and Refrigeration System, Vapor compression Refrigeration Cycle, Refrigerants, Factors Affecting Refrigeration and Air Conditioning System Performance and Savings Opportunities.

Cooling Towers: Types and Performance Evaluation, Efficient System Operation, Flow Control Strategies and Energy Saving Opportunities, Case Studies.

UNIT IV

Bill Analysis: ECO (Energy Conservation Opportunities)

Electricity tariff and components, load Management & Demand Side Control, power factor improvement & its benefit, selection and location of capacitors, Performance Assessment of capacitors & Capacitor Bank.

Lighting Systems: Light source, Choice of Lighting, Luminance requirements, Energy conservation avenues.

Transformers and Electric Distribution: Types of transformers, Transformer losses, Energy efficient transformers, Factor affecting the performance of transformers and Energy Conservation Opportunities, Cables, Switch Gears, Distribution Losses, and energy conservation opportunities in-house electrical distribution system.

UNIT V

Electric Motors:

Energy Saving Opportunities in Motors, Motor Selection, Energy Efficient Motors, Speed Control of AC Induction Motors ,Soft starter with energy savers, Variable Speed Drives(VFD).

Compressed Air Systems:

Types of air compressors, compressor efficiency, efficient compressor operation, compressed air systems components, capacity assessment, and leakage test, factors affecting the performance and Efficiency, energy savings opportunities.

Energy Saving Opportunities in Fans & Blowers, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities

Recommended Books

1. G. L. Witte, Phillips S.Scbmidt and Daid R. Brown, Industrial Energy Management and Utilization, Hemisphere Publishing Corporation, Washington.
2. Carig,B. Saith, Energy Management Principles, Applications, Bnefit and Saving, Per n Press, New York.
3. F. W. Pyne, P *gm* Energy Conservation Manual, Fairmont Proem, INC.P.O. Box 14227 Atlanta,GA 30224

4. D. Patrick and S.W. Fardo, Energy U-sent and Conservation, Prentice Hall, INC Engleweek Cliffs (NJ) 7632.
5. Davida , Fuels Of Opportunity , Characteristics and Uses In Combustion Systems, Edition-2004 Publisher- ELSEVIER LTD. UK
6. O.P. Gupta, Element Of Fuel Furnaces And Refractories, Edition-Second
7. Savings Electricity in Utility Systems of Industrial Plants by B.G. Desai, B.S. Vaidya D.P. Patel and R. Parman.
8. Electrical Power Distribution in Industrial Plants by M.D. Parmar.
9. Energy Conservation in Electrical Systems, a reading material prepared by D. Buddhi.
10. Smalensky , Electrical Machines , Vol-3, MIR Publishers MOSCOW
11. Igor J. Karassik , Pump Hand Book , Third Edition 2001 , Mcgrawn-Hill
12. B.R. Gupta, Generation of Electrical Energy Edition 2005, Eurasia Publishing House (PVT.) LTD. Ram Nagar
13. National Technical Information Services U. S. Deptt. Of Commerce Springfield, VA 22161.
14. Energy Auditing, The Fairmont Press Inc. Published by Atlanta, Georgia
15. Albert Thumann, P.E., C.E.M. , Plant engineers & Managers Guide To Energy Conservation 8th edition-2002, Published By The Fairmont Press , Inc 700 Indian Trail Liburn, GA30047
16. BEE VolumeI –Second Edition 2005
17. G.G. Ranjan: Optimizing Energy Efficiencies in Industry ,Edition-2003 McGraw Hill

EN7B-710: Air and Noise Pollution Control Engineering

Credits: 4 (64 Hours)

UNIT I: Noise Pollution and Control

Sources and Effects of Noise Pollution – Measurement – Standards –Control and Preventive measures. Sources types and control of indoor air pollutants, sick building syndrome types – Radon Pollution and its control. The Decibel Scale, Sound Intensity Level. Classification of Noise, Noise Standards. Effects of Noise, Noise Control Methods, Acoustical Materials, Acoustical Enclosures, Silencers and Muffle Reverberation Control, Personal Hearing Protection Devices, Role of Vegetation in Noise Control.

UNIT II: Air Pollution & Control

Definition of air pollution, Sources and classification of air pollutants, Air Quality, Effects of air pollutants on human health, vegetation & animals, Materials & Structures – Effects of air Pollutants on the atmosphere, Soil & Water bodies – Long- term effects on the planet – Global Climate Change, Ambient Air Quality and Emission Standards – Air Pollution Indices – Emission Inventories. Air Pollution Episodes.

UNIT III: Air Pollution Monitoring

Ambient and Stack Sampling and Analysis of Particulate and Gaseous Pollutants -Effects of meteorology on Air Pollution - Fundamentals, Atmospheric stability, Inversion, Wind profiles and stack plume patterns- Transport & Dispersion of Air Pollutants – Modeling Techniques, Collection of Gaseous Air Pollutants, Collection of Particulate Pollutants, Measurement of SO_x, NO_x, CO, Oxidants and Ozone.

UNIT IV: Air Pollution Control:

Factors affecting Selection of Control Equipment – Gas Particle Interaction, – Working principle, Design and performance equations of Gravity Separators, cyclones, Fabric filters, Particulate Scrubbers, Electrostatic Precipitators – Operational Considerations - Process Control and Monitoring – Costing of APC equipment – Case studies for stationary and mobile sources Wind Circulation, Lapse Rate, Stability Conditions, Maximum Mixing Depths.

UNIT V: Global Concerns, Light Pollution and Thermal Pollution

References:

1) Understanding Environmental Pollution Marquita K.
2) Environmental Pollution and Its Control, COGENT International, 1st edition 1998 S.A. Abbasi
3) Environmental Noise Pollution And Its Control, Anmol Publication 1st edition 1992 Chhatwal G.R.et al
4) Environmental Pollution And Its Control Jeffrey J. and P.A. Vesilind
5) Air Pollution: M. N. Rao & HVN Rao, TATA McGraw Hill Publication, New Delhi, 12th edition, 1998
6) Chemistry for Environmental Engineering Clair N. Sawyer & McCarty, TATA McGraw Hill International Publication IIIrd Edition.1986
7) Environmental Engineering - Howard S. Peavy et.al, TATA McGraw Hill International Publication 1st Edition. 1986.
8) T K Ray, Air Pollution Control in Industries , Vol-1,2
9) J.N.B, Air Pollution and Plant Life.
10) Robert Jennings Heinson, Air Pollution.

EN7B-711: Bio-fuel Technology

Credits: 4 (64 Hours)

Unit I

Biomass & Biomass Management

Biomass availability, Characteristics of Biomass, Bulk chemical Properties (Moisture, ash content, Volatile matter, Fixed carbon, Heating value), Chemical composition (Cellulose, Hemicelluloses, Lignin, Extractible), Structural Properties (Physical Structure, Permeability), Physical properties (True density, Bulk density, particle size distribution, thermal conductivity, heat capacity), Physical Importance for Characterizations of Biomass, Energy Plantation, MNRE Initiative On Energy Plantation

Unit II

Biochemical Process

Aerobic and Anaerobic Bioconversion process, Biogas production process, Effect of Feed and operational parameters, Types of digesters and their suitability, Applications of biogas, Design criterion of some Bio-methanation Plants, optimum sizing of landfill digesters & Gas storage systems.

Unit III

Thermo Chemical Process

Biomass Gasification Process, Types of Gasifiers and their working, Feed and operational parameters on output Gas production, properties producer gas, conditioning & cleaning of

producer gas, Design criterion, design of a Gasifier for thermal application and power application.
Biomass Pyrolysis: Process of slow, fast and Flash Fast Pyrolysis for solid and liquid fuel Production, Technologies for Pyrolysis, Parameters effecting on yield of pyrolyser**,** Upgrading of bio-oil, Applications of Pyrolysis product.

Unit IV

Liquid & Gaseous Bio-fuel

Characteristics of Bio-diesel, Advantages & disadvantages of Bio-diesel over petroleum diesel, Biodiesel Production Process (batch & continuous process), Parameters affecting the Yields of bio-diesel, Bio-diesel Blend, application of biodiesel, biodiesel and Environment, Challenges of biodiesel Industries.

Bio- alcohol: Feed stock for bio-alcohol Production, status of bio-alcohol Production, Cellulosic Ethanol, flow chart for bio-alcohol Production from Different Feedstock, Traditional Method for bio-alcohol production, Technologies for bio-alcohol Production, application of bio-alcohol, advantages & Disadvantages of Bio-ethanol.
Bio-hydrogen: Bio-hydrogen production and its application

Unit V

Composting & Densification of Biomass

Composting: Types of Composting, Parameters which effect composting Process, Compost Systems (Windrow and In-vessel), design of Windrow Composting, Aeration of Windrow Composting, design of In-Vessel Composting System, Characteristics of compost, Application of compost, Constraints on Use of the Compost.
Vermi-composting: Process, Types of Species, Materials and Methods, Characteristics of Manure, Applications.

Densification of Biomass: Status of Biomass Briquetting Technology in India, Advantages of Briquettes, Characteristics of Biomass Residues for Briquetting, Mechanism of biomass Briquetting, Briquetting Technologies (Low density & high density technologies: Piston Press & Screw Press), Parameters Influencing Briquetting Process, Applications of Briquettes.

References:

1. Klaus von Mitzlaff, “Engines for biogas- theory, modification & economic operation” Published by friedr. Vieweg & Sohn Braunschweig/ Wiesbaden.
2. Biomass – Thermo-chemical Characteristics Edited by PVR Iyer; T R Rao; P D Grover and N P Singh, Published by Biomass gasifier Action Research Centre, Dept of Chemical Engineering , IIT Delhi
3. Kaup and Goss (1984) “Small Scale Gas Producer Engine System” Published by Friedr, Vieweg & Sohn Braunschweig/ Wiesbaden.
4. ABETS, IISc, Bangalore (2003) “Biomass to Energy – The science and technology of the IISc Bio-energy systems” Published by Science & Technology of the Indian Institute of Science, Bangalore
5. Reed, T. B. and Das, A. (1988) “Hand book of biomass down draft gasifier engine systems”. Published by Solar Energy Research Institute, U.S. Dept. of Energy
6. K M Mital ,Biogas System - Principles & Applications Published by new Age international (p) Ltd, New delhi

7. Klaus von Mitzlaff, “Engines for biogas- theory, modification & economic operation” Published by friedr. Vieweg & Sohn Braunschweig/ Wiesbaden
8. Orion Polinsky “A Bio-fuels Handbook” Published by Oasis Publishing 2002.
9. Lisbeth Olsson (2007), “Biofuel”, published by Springer- Verlag Berline Heidelberg, New York.
10. Ayhan Demirbas (2008) “Bio-hydrogen: for future engine fuel Demands” published by Springer- Verlag Berline Heidelberg, New York.

EN7B - 712: Environment Laboratory

Credits: 3 (48 hours)

1. pH, Conductivity and Turbidity
2. Hardness : Total Ca, Mg by EDTA Method
3. Alkalinity: HCO_3, CO_3, OH. CO_2 and Combinations
4. Estimation of Nitrate. Nitrogen by PDA Method
5. Ammonical Nitrogen
6. Nitrite Nitrogen
7. Estimation of Phosphates
8. Sulfate by Spectrophotmetric & Turbiditimetric Method
9. Residual Chlorine
10. Chlorine Demand
11. Dissolved Oxygen
12. Biological Oxygen Demand
13. Chemical Oxygen Demand
14. Fluorides by SPADNS Reagent
15. Heavy Metals by AAS
16. Total Organic Carbon by TOC Analyzer
17. Fe, Total Cr, Cr (VI) by UV – Visible Spectrophotometer
18. Microbiological Estimation in given sample using Total Count Method, Streaking Method and Staining Method
19. Estimation of air pollutant such as NOx, SOx , **Particulate Matter (NRD, RSPM)**
20. Determination of Crude Protein in a Given Biomass Sample.
21. Coagulation and flocculation for removal of suspended solids from water.
22. Water softening.
23. Biological aerobic treatment for removal of organic pollutants and determination of sludge volume index

EN7B - 713: Mini Project in Environment

Credits: 4 (64 hours)

In this course, students suppose to work on environmental related issue under the supervision of Expert available in the department. At the end of semester student (s) suppose to submit his/her work report in the form of spiral binding, submit it to Examination In charge and present it (through PPT) in front of the Examiner (s). His/ Her work would be evaluated orally by panel of 02 or more than 02 Examiner.

EN7B -714: Heat & Mass Transfer

Credits: 3 (48 hours)

Unit I: Basic Heat Transfer Concept and Terminology:

Basic Concepts Terminology, Heat Transfer Coefficients, Thermal Resistance, Overall Heat Transfer Coefficient.

Conduction: Conduction Equation, Steady State Conduction in simple geometries, Thermal; Contact Resistance ,Critical Thickness of Insulation, Multidimensional Steady State Heat Conduction (Shaper Factor), Types of Fins, Effectiveness and Efficiencies of Fins Area Weighted Fine Efficiency, Transient Heat Conduction ,Lumped Heat Capacity Analysis, Heiler's Charts for Semi-Infinite Medium, Slab Cylinder and Sphere, Periodic Heat Conductions.

Unit II: Convection:

Similarity Principle, Mass moments and Energy Balance equations, Evaluation of Dimensionless Parameters, Forced Flow Convection (Laminar, Turbulent &Mixed) Thermal and Velocity Boundary Layer Thickness Convective Heat Transfer Coefficient ,Drag Coefficient for Flat Plate, Inside tube , Cylinder, Sphere and banks of tubes, Free convection (Laminar, Turbulent &Mixed) on horizontal Verticals and Inclined Plates, Inclined Parallel Plates, Horizontal, Verticals, Cylinder and Sphere ,Two Phase Convection :Phase Condensation on vertical and Single Tube, Bank of Tube Boiling.

Unit III: Radiation, Pinch Technology and Process Integration

Blackbody Radiation, View Factor Algebra, Enclosures with Black Surfaces and Grey Surfaces, Radiosity, Heat Exchangers and its Types, Effectiveness, LMTD and NTU Methods.

Principle of pinch Technology , Stream Network, Design of Energy Recovery System, Selection of Pinch Temperature Difference: Graphical and Tabular Methods, Stream Splitting, Process Retrofit Application, Installation of heat pump and engines, Grand Composite Curves.

Unit IV: Diffusion and Mass Transfer

Molecular Diffusion in Liquids, Mass Transfer Coefficient Diffusion in Solids, Interphase Mass Transfer, Mass Transfer and Chemical Reaction Evaporation, Unsteady State Processes Steady State Processes.

Unit V: Gas – Liquid Operations

Gas Absorption, Distillation, Humidification Equipments: Gas Dispersed, Sprayed Vessels (Bubble Columns), Mechanically Agitated Vessels (Single Phase Liquids, Gas Liquid Contacts) Equipments: Liquid Dispersed - Venture Scrubbers, Water Wall Towers, Spray Towers / Chambers, Packed Towers.
Liquid Extraction: Liquid Equlibria, Equipment, Adsorption and Exchange of solid fuel, Drying Leading and Extraction, Crystallization, Equipment.

Recommended Books

1.Mass Transfer Operations By Robber E Tvegbol Pub: Mcgraw – Hill
2.Unit Operations Of Chemical Engineering By Mccobe, Smith
3.Chemical Process: Design And Engineering By Robin Smith Pub: John Wiley & Sons, Harriott, Pub McGraw - Hill
4.M.N. Oziesik, Heat Transfer - A Basic Approach, McGrew Hill Book Co., New Delhi.
5.M. Becter, Heat Transfer: A Modem Approach
6.S.P. Shukatme, Heat Transfer, Orient Longman, New Delhi.
7.W.H. Giedt, Principles of Engineering Heat Transfer, D.Van Norstand Company Inc.(1961)
8.F. Kireth, Radiation Heat Transfer, International Text book Co., Semton, USA (1962).

EN7B-715: Comprehensive Viva-Voce

Credits: 4 (64 hours)

Comprehensive Viva-Voce: At the end of each semester student (s) knowledge gain during the semester would be evaluated orally by panel of 04 Examiner, which include 01 External and 3 internal Examiner.

EN7B-801: Green Building Design & Simulation

Credits: 4 (64 Hours)

Unit I: Green Building Design Strategies and Building Codes

Energy use in Buildings, Factors effecting Energy use, Energy Conservation options. External Factors – Climate, Building Orientation, Shading, types of shading devices.

Unit II Thermal Comfort:

Criteria and various Parameters, Psychometric Chart, Thermal Indices. Indoor air quality; Requirements in residential, Commercial, Hospital Buildings.

Unit III Heating Cooling Concepts

Passive heating concepts: Direct gain, indirect gain, isolated gains and suspense
Passive cooling concepts: Evaporative Cooling, Evaporative Air and Water Coolers, Radiative Cooling, Application of Wind, Water and Earth for Cooling ,use of isolation, Shading, Paints and cavity walls for cooling;
Passive heating and cooling concepts: Roof pond/sky therm, roof radiation trap, vary-therm wall, earth sheltered or earth based structures and earth air tunnels; selective ventilation, components- windows and thermal storage

Unit IV Heat Transmission in Buildings:

Surface Coefficient, Air cavity, Internal and External Surface, Overall Thermal Transmittance Walls and Windows, and Packed Roof-thatched Heat Transfer due to ventilation/ infiltration, Building loss coefficient Internal Heat gains, Solar Temperature, Steady State Method (for Trombe Wall, Water wall and Solarium), Degree Day method

Unit V Modeling of Building:

Correlation methods - solar load ratio, load collector ratio, thermal time constant method, Analytical methods - thermal circuit analysis, admittance procedure of metrics. The periodic solutions - thermal modeling of AC / Non AC buildings, software application. ASHRAE Methods and standards for estimates of Heating and cooling and Ventilation, Requirements of Different use Buildings, Air Quality control Equipments, Typical Designs of Selected Buildings in various Climatic Zones, Thumb Rules for Design of Building systems.

Evaluation methods: LEED methodology, BEE star rating, GERRHA Methodology
Case Studies

Recommended Books

1. M S Sodha, N.K. Banaal, P.K.Bansal, A.Rumaar and M.A.S. Malik, Solar Passive: Building Science and Design, Pergamon Preen (1986).
2. Jamee; L. Threlked, Thermal Environment Engineering, Prentice Hall, INC-, Raglevood Cliffs, New Jersey (1970)
3. T.A. Markus and R.N. Morris, Building, Climate and Energy Spottwoode Ballantype Ltd-, London U.K. (1980)
4. Solar Thermal Energy Storage, H. P. Garg et.al, D. Reidel Publishing Company (1985)
5. Mathematical Modeling of Melting and Freezing Process, V Alexiades & A.D. Solomon, Hemisphere Publishing Corporation, Washington (1993)
6. Energy storage technologies, a reading material prepared by Dr. D. Buddhi, School Of Energy And Environmental Studies, DAVV, Indore.

EN7B-802: Solid and Hazardous Waste Management

Credits: 4 (64 hours)

UNIT - I: **Solid Waste Generation and Collection**

Solid wastes: Definition, types, sources, classification and composition of solid waste, Types and Sources of solid and hazardous wastes and impact on environmental health. Waste generation rates. Collection and storage of municipal solid wastes, Handling and segregation of wastes at source. Concepts of waste reduction, recycling and reuse.

UNIT - II: **Solid Waste Treatment and Disposal**

Solid waste processing technologies. Mechanical and thermal volume reduction. Biological and chemical techniques for energy and other resource recovery. Composting, Vermi-composting, Sanitary land filling: site selection, design, and operation of sanitary landfills; secure landfills and landfill bioreactors; leachate and landfill gas management; landfill closure and post-closure environmental monitoring; landfill remediation, Incineration of solid wastes. Recycling of household and commercial waste, recycling of paper, recycling of tire, recycling of plastics, recycling of Aluminum can.

UNIT - III: **Solid Waste Management Legislation**

Need for solid and hazardous waste management –- Salient features of Indian legislations on management and handling of municipal solid wastes, Solid waste management plan, Municipal Solid Waste (Management and Handling) Rules, 2000, 2015, Hospital waste management, Biomedical Waste (Management and Handling) Rules, 1988; Fly ash management, Fly ash Management Rules, (1999), recycled plastic usage rules, batteries (management and handling) rules.

UNIT - IV: **Hazardous Waste Management**

Definition of hazardous wastes, Sources, classification, collection, segregation, characterization of Hazardous waste, Physicochemical properties of hazardous waste needed in management. Hazardous waste control, treatment and management,

Nuclear Waste: Sources, classification, collection, segregation, Treatment and Disposal. E-waste: Sources, classification, collection, segregation, Treatment and Disposal. Hazardous Waste (Management and Handling) Rules (1989) and (2000) Amendments.

UNIT IV: Solid Waste Processing Technologies

Solid waste material separation and processing technologies – biological and chemical conversion technologies – methods and controls of Composting - thermal conversion technologies and energy recovery – incineration – solidification and stabilization of hazardous wastes - treatment of biomedical wastes, Landfills - Landfill Classification, types and methods – site selection - design and operation of sanitary landfills, secure landfills and landfill bioreactors – leachate and landfill gas management – landfill closure and environmental monitoring.

References:

1. K.L. Wang & N.C. Periera, Handbook of Environmental Engineering, Vol. 2, Solid waste processing & recovery. The Humane press, Cliton, New Jersey.
2. N.C. Cheremenisoff, P.N. Cheremenisoff & F. Ellurbrush, Biomass- Application, technology & production, Marcel Dekker, New York, 1980.

3. W. Salonas & Frostner D., Environmental Management of Solid waste- dredged material & tail minings. Springer_Yedag,New York, 1988.
4. G. Technobanogalous, H.Vigil. & T. Theilsein, Integrated Solid waste management collection, disposal & reuse, McGraw Hill, 1994
5. Handbook of solid management" Frank Kerith, McGraw Hill, Inc. USA (1994).
6. Hazardous Waste Management – Charles A. Wentz
7. T V Ramchandra- Management of Municipal Waste
8. Solid Waste Management Manual CPCB, New Delhi.
9. Ecotechnology for Pollution Control and Environmental Management by Trivedy R.K. and Arvind Kumar.
10. Williams, Paul T. (2013) Waste treatment and disposal, John Wiley Publishers.
11. Johri, Rakesh (Ed.), (2009) E-waste : Implications, regulations and management in India and Current global best practices, TERI press.
12. Letcher, Trevor M. (Ed.) (2011) Waste: A handbook for management, Academic Press London. 6. Sahai, Sushma (2009) Bio- medical waste management, APH Publishing.
13. Rosenfeld, Paul E., (2011) Risks of hazardous wastes, Elsevier London.
14. R E Hester (ed.); Roy M Harrison (ed.) (2008) Electronic waste management: design, analysis and application, Cambridge Royal Society of Chemistry.
15. George Tchobanoglous, Hilary Theisen and Samuel A, Vigil, "Integrated Solid Waste Management, Mc-Graw Hill International edition, New York, 1993.
16. CPHEEO, "Manual on Municipal Solid waste management, Central Public Health and Environmental Engineering Organization Government of India, New Delhi, 2014.
17. William A. Worrell, P. Aarne Vesilind, Solid Waste Engineering, Cengage Learning, 2012.
18. Michael D. LaGrega, Philip L Buckingham, Jeffrey C. E vans and "Environmental Resources Management, Hazardous waste Management", Mc-Graw Hill International edition, New York,2010.
19. John Pitchtel,Waste Management Practices, CRC Press,Taylor and Francis Group,2014.
20. Frank Kreith, George Tchobanoglous ,Handbook of Solid Waste management, Mc Graw Hill, 2002

EN7B-803: Unit Operation & Unit Process in Environmental Technology

Credits: 4 (64 hours)

UNIT I: Selection of unit operations and processes - Principal type of Reactors -Screening - Mixing - Coagulation and Flocculation – Flow equalization

UNIT II Sedimentation - Type of settling - Removal ratio – Clarifier-thickener- Column flotation- air flotation. Design approach: Clarifier, Tube settler.

UNIT III: Filtration – classification of filters-Head loss through filters– Darcy equation. Design approach: Activated carbon fillers, Filter press, Pressure sand filter.

UNIT IV: Chemical precipitation - phosphate removal - Adsorption - Activated carbon - Isotherms – Disinfection – Factors Influencing - Breakpoint chlorination - Dechlorination. Design approach: UV disinfection, water chlorination

UNIT V: Kinetics of Biological growth - Suspended and attached growth processes - Aerobic and Anaerobic - Determination of kinetic coefficients. Design approach: Aeration equipments, anaerobic digester, UASBR, Secured land fill

REFERENCES

1. Casey. T.J. "Unit Treatment Processes in Water and Wastewater Engineering ", John Wiley & Sons, 2006.

2. METCALF & EDDY, INC. "Wastewater Engineering - Treatment, Disposal, and Reuse ", Fourth Edition, Tata McGraw-Hill, 1995. ES5111 ENVIRONMENTAL

EN7B- 804: Energy Environmental Audit & Impact Assessment

Credits: 4 (64 hours)

UNIT - I: Environmental Impact Assessment

Environment Impact Assessment (EIA) - Principles, Origin, development, types, issues, problems and limitations, environmental risk assessment, environmental management plan, environmental impact statement (EIS), Strategic Environmental Assessment (SEA), EIA guidelines (1994) and notifications (Govt. of India 2006), Scope of EIA in project planning and implementation, Indian directions of EIA, Monitoring tools for EIA, surveys, spatial databases, experiments, models, Decision support system, Sources and collection of data for EIA, various appendices and forms for application.

Unit – II: EIA Methodology

Components of EIA, EIA methodology – project screening, scoping, base line data, impact identification, prediction, evaluation, mitigation. Assessment techniques – cost benefit analysis, analysis of alternatives, methods of prediction matrices, networks, checklists and overlays and assessment of impacts – air, water, soil, noise, biological, social, cultural, economical, environmental factors. EIA standards and guidelines, public participation- procedure of public hearing, presentation, review and decision making. Quality control – trends in EIA practice, evaluation criteria, expert system in EIA, use of regulations. Documentation and monitoring – Generic structure of EIA Document, planning, collection, use of display materials, team writing, checklist, environmental monitoring guidelines and policies, Environment management plan, post audit.

Unit -III: Environmental Impact Assessment and Risk Analysis

Environmental Appraisal procedures in India, Impact identification methods. Environmental impacts of mining industry ; nuclear power plant; textile industry; petroleum refining; fertilizer industry ; Case study – EIA of Hydroelectric dam and river valley projects; thermal power plants. Definition of risk, environmental risk analysis – risk assessment and risk management. Basic steps in risk assessment – hazard identification. Dose-response assessment, exposure assessment, risk characterization. Risk assessment in EIA.

Unit - IV: Environmental Auditing

Definition and types of audits, Guidelines for environmental auditing, methodologies for Environmental Auditing, Matrix methods and Batelle method of auditing, Types of projects requiring Environmental Clearance, EAC, EIA case studies, Legal requirements for

environmental auditing. Restoration and rehabilitation technologies, Environmental planning, urban planning, rural planning and land use pattern.

EN7B - 805: Mini Project in Energy

Credits: 4 (64 hours)

In this course, students suppose to work on Energy related issue under the supervision of Expert available in the department. At the end of semester student (s) has to submit his/her work report in the form of spiral binding, submit it to Examination In charge and present it (through PPT) in front of the Examiner (s). His/ Her work would be evaluated orally by panel of 02 or more than 02 Examiner.

EN7B -806: Economics of Energy and Environment Systems

Credits: 3 (48 hours)

Unit – I Sustainable Development: Introduction to sustainable development - Economy-Environment inter-linkages - Meaning of sustainable development - Limits to growth and the environmental Kuznets curve - The sustainability debate - Issues of energy and the economics of energy – Non-renewable energy, scarcity, optimal resources, backstop technology, property research, externalities, and the conversion of uncertainty.

Unit – II Environmental Degradation & biodiversity: Economic significance and causes of environmental degradation - The concepts of policy failure, externality and market failure - Economic analysis of environmental degradation - Equi-marginal principle, Economics of Climate Change – stren Report

Unit – III Economics of Pollution: Economics of Pollution - Economics of optimal pollution, regulation, monitoring and enforcement - Managing pollution using existing markets: Bargaining solutions - Managing pollution through market intervention: Taxes, subsidies and permits.

Unit – IV Cost – Benefit Analysis: Economic value of environmental resources and environmental damage - Concept of Total Economic Value - Alternative approaches to valuation – Cost-benefit analysis and discounting.

Unit – V Energy Economics – Energy Economics - Simple Payback Period, Time Value of Money, IRR, NPV, Life Cycle Costing, Cost of Saved Energy, Cost of Energy generated, Examples from energy generation and conservation, Energy Chain, Primary energy analysis Life Cycle Assessment & Costing, Net Energy Analysis Environmental Impacts of energy use , Financing Options, Energy Performance Contract and Role of ETCOS.

Reference Books

1.D.W. Pearce, A. Markandya and E.B. Barbier (1989), Blueprint for a Green Economy, Earthscan, London.

2.R.K. Turner, D.W. Pearce and I. Bateman (1994), Environmental Economics: An Elementary Introduction, Harvester Wheatsheaft, London.

3.D.W. Pearce and R.K. Turner (1990), Economics of Natural Resources and the Environment, Harvester Wheatsheaf, London.

4.Michael S. Common and Michael Stuart (1996), Environmental and Resource Economics: An Introduction, 2 nd Edition, Harlow: Longman. Roger Perman, Michael Common, Yue Ma and James McGilvray (2003), Natural Resource and Environmental Economics, 3 rd Edition, Pearson Education.

5.N. Hanley, J. Shogren and B. White (2001), An Introduction to Environmental Economics, Oxford University Press.

6.Energy and the Challenge of Sustainability, World energy assessment, UNDP New York, 2000.

7.AKN Reddy, RH Williams, TB Johansson, Energy after Rio, Prospects and challenges, UNDP, United Nations Publications, New York, 1997.

8.Nebojsa Nakicenovic, Arnulf Grubler and Alan McDonald Global energy perspectives, Cambridge University Press, 1998.

9.Fowler, J.M., Energy and the environment, 2nd Edn., McGraw Hill, New York, 1984

EN7B-807: Comprehensive Viva-Voce

Credits: 4 (64 hours)

Comprehensive Viva-Voce: At the end of semester student (s) knowledge gain during the semester would be evaluated orally by panel of 04 Examiner, which include 01 External and 3 internal Examiner

EN7B - 808: Major Project

Credits: 12 (192 hours)

In this course, students would be sent to industries for internship for about 06 months, where they would get in hand practical knowledge of industrial problems, handling it and working for it solution. At the end of semester student (s) suppose to submit his/her work report in the form of hard binding, submit it to Examination in charge and present it (through PPT) in front of the panel of Examiner (s). His/ Her work would be evaluated orally by panel of Examiner (s), in which one External Examiner is compulsory.

EN7B-809: Comprehensive Viva-Voce

Credits: 4 (64 hours)

Comprehensive Viva-Voce: At the end of semester student (s) knowledge gain during the semester would be evaluated orally by panel of 04 Examiner, which include 01 External and 3 internal Examiner.