JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
DEPARTMENT OF MECHANICAL ENGINEERING
M. Tech. (Centre for Energy Studies)
2018-19 Admitted Batch

Semester – I

Course Number	Subject	Scheme of Studies Per Week			Credits
		L	T	P	
1ES01	Program Core-I Renewable Energy Technologies	3	0	0	3
1ES02	Program Core-II Modern Control Systems	3	0	0	3
1ES11	Program Elective I Engineering Heat transfer / Thermal Power Plant / Waste Management and Recycling	3	0	0	3
1ES12	Program Elective II Energy Management and Conservation / Applied Thermodynamics / Environmental Pollution and Control	3	0	0	3
1A111	Research Methodology and IPR	2	0	0	2
1A112	Audit Course English for Research Paper Writing	2	0	0	0
1ES03	Laboratory 1 (Based on Core) Renewable Energy Laboratory	0	0	4	2
1ES04	Laboratory 2 (Based on Elective) Energy Computational laboratory	0	0	4	2
	Total	**16**	**0**	**8**	**18**
Total Credits : 18					

Semester – II

Course Number	Subject	Scheme of Studies Per Week			Credits
		L	T	P	
2ES05	Program Core III Direct Energy Conversion	3	0	0	3
2ES06	Program Core-IV Energy Efficiency in Thermal Systems	3	0	0	3
2ES13	Program Elective III- Energy Efficiency in Electrical Utilities / Nuclear Power Plants / Measurements in Energy Engineering	3	0	0	3
2ES14	Program Elective IV- Optimization of Energy Systems / Wind Energy Conversion Systems / Solar Thermal Processes	3	0	0	3
2A113	Audit Course Value Education	2	0	0	0
2ES07	Laboratory 3 (Based on Core) Energy Conversion Laboratory	0	0	4	2
2ES08	Laboratory 4 (Based on Elective) Computer Simulation Lab	0	0	4	2
2ES09	Mini Project with Seminar	2	0	0	2
	Total	**16**	**0**	**8**	**18**
Total Credits : 18					

Semester – III

Course Number	Subject	Scheme of Studies Per Week			Credits
		L	T	P	
3ES15	Program Elective V Smart Grid Technologies / Energy Storage Systems Hydrogen and Fuel Cells	3	0	0	3
3ES02	Open Elective Waste to Energy	3	0	0	3
3ES10	Dissertation-I/Industrial Project	0	0	20	10
Total Credits: 16					

Semester – IV

	Subject	Scheme of Studies Per Week			Credits
		L	T	P	
	Dissertation II	0	0	32	16
Total Credits:16					

RENEWABLE ENERGY TECHNOLOGIES

M.Tech, ES. I-Sem

L	T	P	C
3	0	0	3

Teaching scheme
Lecture: - 3 h/week

Course Code	**1ES01**
Course Name	**RENEWABLE ENERGY TECHNOLOGIES**

Course objectives:

- To explain the concepts of Non-renewable and renewable energy systems
- To outline utilization of renewable energy sources for both domestic and industrial applications
- To analyse the environmental and cost economics of renewable energy sources in comparison with fossil fuels.

LECTURE WITH BREAKUP

Unit1:

Fundamentals of Energy: Energy consumption and standard of living, Oil crisis, Classification of energy resources, Consumption trend of primary energy resources, conventional energy sources and their distribution, Energy chain, common forms of energy, importance and salient features of non-conventional energy resources, environmental aspects of energy, Environment-economy-energy and sustainable development, Energy densities of various fuels, World energy status, Energy scenario in India.

Unit 2:

Solar energy: Solar energy basics, Sun-Earth relation spectrum, Terrestrial and extra-terrestrial radiation, spectral energy distribution of solar radiation, Depletion of solar radiation, measurement of solar radiation, solar radiation data, Solar time, Solar radiation geometry, Solar day length, Empirical equations for estimation of solar radiation on horizontal surfaces, Global, diffused and beam radiation, Solar radiation on inclined surface (Problems on energy availability on surfaces)

Unit 3:

Wind Energy: Wind origin, nature, types, Wind data and wind rose, wind speed variation, Wind siting Wind turbine classification and types of rotors, Wind turbine aerodynamics, power extraction from wind, Betz criteria, Axial thrust on the turbine, torque developed by the turbine, Dynamic matching, speed control strategies, Wind turbine operational characteristics, wind energy conversion systems, environmental aspect, Wind energy potential and installation in India (Problems on energy Conversion)

Unit 4:

Biomass Energy: Biomass resources and their classification**,** Biomass conversion technologies: Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion – operational parameters of biogas plants, Types of biogas Plants and biogas plant design – Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy program in India (Problems on biogas plant design)

Unit 5:

Ocean Energy: Origin and nature of tidal energy, Tidal range power, tidal energy conversion schemes - Principle of Ocean Thermal Energy Conversion (OTEC) - Ocean thermal power plants-wave energy, power in waves, wave energy technologies- Geothermal power plants - Various types.

Small Hydro Power Plant: Importance of small hydro power plants and their Elements - Types of turbines for small hydro - Estimation of primary and secondary power.

COURSE OUTCOMES

Student have

1. An understanding of renewable energy sources
2. A knowledge of working principle of various energy systems
3. A capability to carry out basic design of certain renewable energy systems

Text Books:

1. Renewable Energy Sources, Twidell, J.W. and Weir, A., EFN Spon Ltd., 1986.
2. Renewable Energy Engineering and Technology, Kishore VVN, Teri Press, New Delhi, 2012
3. Renewable Energy Power for a Sustainable Future, Godfrey Boyle, Oxford University Press, U.K, 1996.

Reference Books:

1. Solar Energy - Principles of thermal collection and storage, S. P. Sukhatme
2. Solar Engineering of Thermal Processes, J. A. Duffie and W. A. Beckman
3. Principles of Solar Engineering, Kreith, F and Kreider, J. F., McGraw-Hill, 1978.
4. Renewable Energy, Bent Sorensen, Elsevier, Academic Press, 2011
5. Power Plant Technology, J Wakil
6. Non-Conventional Energy Sources, G.D Rai

MODERN CONTROL SYSTEMS

M.Tech, ES. I-Sem

L	T	P	C
3	0	0	3

Teaching scheme
Lecture: - 3 h/week

Course Code **1ES02**
Course Name **MODERN CONTROL SYSTEMS**

Course objective

- To understand the concepts of linear control systems.
- To study about controllability and observability and their application to different control systems.
- To study about non-linear control systems and also to obtain stability analysis.

LECTURE WITH BREAKUP

UNIT-1 INTRODUCTION: Concepts of Control Systems- Open Loop and closed loop control systems and their differences- Different examples of control systems- Classification of control systems- Feed-Back Characteristics- Effects of feedback. Mathematical models – Differential equations - Impulse Response and transfer functions - Translational and Rotational mechanical systems.

TRANSFER FUNCTION EPRESENTATION: Transfer Function of DC Servo motor - AC Servo motor- Synchro transmitter and Receiver- Block diagram representation of systems considering electrical systems as examples - Block diagram algebra – Representation by Signal flow graph - Reduction using mason's gain formula.

UNIT-2 TIME RESPONSE ANALYSIS: Standard test signals - Time response of first order systems – Characteristic Equation of Feedback control systems, Transient response of second order systems - Time domain specifications – Steady state response - Steady state errors and error constants – Effects of proportional derivative, proportional integral systems.

UNIT - 3 STABILITY ANALYSIS: The concept of stability - Routh stability criterion – qualitative stability and conditional stability.

Root Locus Technique: The root locus concept - construction of root loci-effects of adding poles and zeros to G(s) H(s) on the root loci.

Frequency Response Analysis: Introduction- Frequency domain specifications-Bode diagrams-Determination of Frequency domain specifications and transfer function from the Bode Diagram-Phase margin and Gain margin-Stability Analysis from Bode Plots.

UNIT-4

STABILITY ANALYSIS IN FREQUENCY DOMAIN: Polar Plots- Nyquist Plots and applications of Nyquist criterion to find the stability - Effects of adding poles and zeros to G(s)H(s) on the shape of the Nyquist diagrams.

Classical Control Design Techniques: Compensation techniques – Lag- Lead- and Lead-Lag Controllers design in frequency Domain- PID Controllers

UNIT – 5

STATE SPACE ANALYSIS OF CONTINUOUS SYSTEMS: Concepts of state- state variables and state model- derivation of state models from block diagrams, Diagonalization- Solving the Time invariant state Equations- State Transition Matrix and its Properties.

COURSE OUTCOMES

Students obtain

1. knowledge on control techniques which are applicable to all phases of life including energy systems
2. An exposure to both linear and non-linear advanced control techniques

Text Books:

1. Control Systems Engineering, I.J. Nagarath and M.Gopal, New Age International (P) Ltd.
2. Modern Control Engineering, K. Ogata, Prentice Hall of India, *3rd* edition, 1998

Reference Books:

1. Automatic Control Systems, Benjamin C. Kuo, John Wiley, 2009
2. Control systems, N.K. Sinha, New Age International Publishers, 3rd edition
3. Modern Control System Theory, M. Gopal, New Age International Publishers, 2nd edition, 1996
4. Modern control System, Dorf, Pearson.

ENGINEERING HEAT TRANSFER
(Program Elective - I)

M.Tech, ES. I-Sem

L	T	P	C
3	0	0	3

Teaching scheme
Lecture: - 3 h/week

Course Code **1ES11**
Course Name **ENGINEERING HEAT TRANSFER**

Course objective

- To understand the fundamental laws of Heat transfer modes
- To develop the skills to correlate the Physics with applications

LECTURE WITH BREAKUP

Unit 1:

Conduction: Introduction – Modes of heat transfer – Basic Equations - Combined modes – Steady one-dimensional – Steady heat source system – Conduction Shape Factor - Unsteady heat conduction - Lumped heat capacity system - Infinite solid flat plate - cylinder (Heisler charts).

Types of fins – Analysis of fins of uniform cross section, effectiveness - Efficiency of fin. Applications**.**

Unit 2:

Forced Convection: Flow with heat transfer - Flat Plate - Boundary layer - Laminar and Turbulent Flow - Forced convection over a flat plate – External Flow – Internal Flow - Empirical relations.

Free convection - Free convection from vertical and horizontal surfaces - Enclosed spaces. Applications to flat plate Collectors.

Unit 3:

Radiation: Overview of Mechanism – laws of radiation- Radiant heat exchange in gray - non-gray bodies – Furnaces – Performance terms and definitions – Furnace heat balance method – Factors affecting furnace performance

Unit 4:

Boiling Heat Transfer: Regimes of pool boiling – Correlations – Boilers – Performance terms and definitions – Reference standards – Direct Method of Testing – Boiler Efficiency Calculation.

Condensation: Types - Film condensation on horizontal and vertical surfaces - Condensers.

Unit 5:

Heat Exchanger: Definition and classification – Heat Exchanger Types by flow design, construction and application - Concept of LMTD and overall heat transfer coefficient - Fouling factor- Derivation of LMTD and effectiveness for parallel and counter flow heat exchangers - NTU approach and design procedure. Purpose of the Performance Test - Performance terms and definitions – Industrial Heat Exchangers - Methodology of heat exchanger performance assessment.

COURSE OUTCOMES

Student will be able

1. To use the concepts of Heat Transfer and fluid flow in the field of energy applications

Text Books:

1. Heat transfer, Cengel and Ghajar, Tata McGraw Hill
2. Heat Transfer - A basic approach, Necati Ozisik, Mc Graw Hill

Reference Books:

1. Fundamentals of Heat and Mass transfer, Incropera and Dewit, Wiley
2. Heat Transfer, Ghoshdastidar, Oxford University Press
3. Convective Heat Transfer Analysis, Patrick H.Oosthuizen, David Naylor, Mc Graw Hill
4. Engineering heat and mass transfer, Mahesh M Rathore, Laxmi Publications
5. Energy Efficiency In Thermal Utilities (Book 2)
6. Energy Performance Assessment For Equipment And Utility Systems (Book 4)

THERMAL POWER PLANT
(Program Elective - I)

M.Tech, ES. I-Sem

L	T	P	C
3	0	0	3

Teaching scheme
Lecture: - 3 h/week

Course Code **1ES11**
Course Name **THERMAL POWER PLANT**

Course objective

- To obtain knowledge on power generation techniques
- To suggest suitable methods to improve the performance of thermal power plants

LECTURE WITH BREAKUP

Unit1:

Fuels and Combustion: Types of fuels – Coal firing – Pulverization of solid fuels – Fuel handling systems – Coal cycle – Ash cycle – Types of Furnaces – Fluidized Bed Combustion (FBC) – Liquid and gaseous fuels – Byproducts of combustion (simple problems) – Heat of combustion – Combustion temperatures – Stack.

Unit 2:

Steam Generators and Accessories: Steam generators – Classification – Types – High-pressure boilers – Super critical boilers – Steam piping Accessories - Super heaters – Re-heaters – Economizers – Air Preheaters - Pumps and Fans - Types of Condensers – Direct contact condensers - Surface condensers - Feed water heaters – Types – Boiler Makeup – Evaporators - Condensate circulation system – Cooling towers – Types – Wet and dry cooling towers.

Unit 3:

Steam Turbines: Classification – Steam Compounding - Advantages and disadvantages – Governing – Turbine losses – Turbine efficiencies – Turbine materials.

Gas turbines: Open and Closed Cycle gas turbines – Design for high temperature - Combined cycles with heat recovery boiler – Combined cycle for power plant – Combined cycle with multi pressure steam - Influence of component efficiencies on cycle performance – IGCC plant.

Unit 4:

Power Plant Performance: General layout of modern thermal power plants – Components / Equipment in thermal power plant – Coal Mills – Boiler – Draft system – Water pumping system – LP and HP heaters – Turbine – Condenser -– Performance terms and definitions - Performance Evaluation.

Unit 5:

Environmental Aspects

Environmental aspects of thermal power plants - Constituents of the atmosphere – Ash and Dust handling - Oxides of Sulfur, Nitrogen and Carbon – Greenhouse effect – Acid precipitation – Particulate matter – Electrostatic precipitators – Thermal pollution.

COURSE OUTCOMES

Students will be able to get

1. Exposure to different cycles and their working principle related to thermal power plants

Text Books:

1. Power Plant Engineering, P.K.Nag / Tata McGraw Hill.
2. Energy Efficiency In Thermal Utilities (Book 2)
3. Energy Performance Assessment For Equipment And Utility Systems (Book 4)

Reference Books:

1. A course in Power Plant Engineering, Arora and Domkundwar, Dhanpat Rai.
2. Power Plant Technology, El Wakil/ Mc Graw Hill.
3. Power Plant Engineering, G.R. Nagpal/Khanna Publishers.
4. Power Plant Technology, Rajput.

WASTE MANAGEMENT AND RECYCLING
(Program Elective – I).

M.Tech, ES. I-Sem **L T P C**
3 0 0 3

Teaching scheme
Lecture: - 3 h/week

Course Code **1ES11**
Course Name **WASTE MANAGEMENT AND RECYCLING**

Course objective

- To make the students realize the importance of treatment
- To get an exposure to disposal and energy recovery of waste from various industries including agriculture through the knowledge of processes,
- To know about Equipment and Materials used in industrial waste – Characteristics & Composition of industrial waste and the pollution control techniques.

LECTURE WITH BREAKUP

Unit1:

Integrated Solid Waste Management: Solid waste in history – Economics and solid waste – Legislation and regulation – Materials flow – Reduction – Reuse – Recycling – Recovery – Disposal of solid waste in landfills – Energy conversion – The need for integrated solid waste management – Special wastes.

Unit 2:

Landfills: Planning, siting and permitting of landfills – Planning – Siting – Permitting – Landfill processes – Biological degradation – Leachate production – Gas production – Landfill design – Liners – Leachate collection – Treatment and disposal – Landfill gas collection and use – Geotechnical aspects of landfill design – Storm water management – Landfill cap – Landfill operation – Landfill equipment – Filling sequences – Daily cover – Monitoring – Post closure care and use of old landfills – Landfill mining.

Unit 3:

Process Effluents: Manufacturing process and sources of effluent from the process of industries like chemical – Fertilizer – Petroleum – Petrochemical –Paper –Sugar – Distillery – Textile – Tannery – Food processing – Dairy and steel manufacturing – Characteristics and composition of effluent and different methods of treatment & disposal of effluent for the following industries steel – Petroleum refineries – Textiles – Tanneries - Atomic energy plants and other mineral processing industries.

Unit 4:

Waste Water Treatment Methods: Nitrification and de-nitrification – Phosphorous removal – Heavy metal removal – Membrane separation process – Air stripping and absorption processes – Special treatment methods – Disposal of treated waste.

Unit 5:

Environmental Issues in Agriculture: Types of farming systems – Agro meteorology – Water and nutrients requirement – Fertilizers – Types of fertilizers – Pesticides and other agrochemicals – Solid and water conservation practices.

COURSE OUTCOMES

Students shall be able

1. To Categorize the waste from various industries & recycle for energy extraction.

Text Books:

1. Industrial Solid Waste Management and Landfilling practice, M. Dutta, B.P. Parida, B.K. Guha and T. R. Surkrishnan. Narosa Publishing House, New Delhi (1999).
2. Environmental Pollution
3. Control Engineering, C.S.Rao Wiley Eastern Ltd. New Delhi (1995).

Reference Books:

1. Industrial Waste Water Pollution Control, W. Wesley Eckenfelder Jr., McGraw Hill,2000.
2. Wastewater Treatment for Pollution Control, McGraw- Hill, Arceivala, S.J.,1998. M. N. Rao & Datta, Waste Water Treatment, 3rd Edition, Oxford & IBH publishing Company Pvt Ltd.
3. Treatment of Industrial Effluent, Callegy, Forster and Stafferd, Hodder and Stonghton, 1988.
4. Hand book of solid waste management and Waste Minimization Technologies Nicholas P. Chermission off. An imprint of Elsevier, New Delhi (2003).
5. Solid Waste Engineering, P. Aarne Vesilind, William A. Worrell and Debra R. Reinhart. Thomason Asia Pte Ltd. Singapore (2002).
6. Design, Construction and Monitoring of Landfills, Amalendu Bagchi,.John Wiley and Sons..,New York. (1994).

ENERGY MANAGEMENT AND CONSERVATION
(Program Elective – II)

M.Tech, ES. I-Sem

L	T	P	C
3	0	0	3

Teaching scheme
Lecture: - 3 h/week

Course Code	**1ES12**
Course Name	**ENERGY MANAGEMENT AND CONSERVATION**

Course objective:

- To get exposure to energy management and conservation principles

LECTURE WITH BREAKUP

Unit1:

Energy Management: Energy Scenario - Energy needs of Growing Economy – Energy Security – Energy Conservation and its importance – Energy strategy for future energy needs - Energy Conservation Act, 2001 and its features - Responsibilities and duties of Energy Manager as per Act - Activities in Energy Management (Formation of Energy Team, Institute Energy Policy, Data Collection and management, Establishing Baseline, Benchmark, Analysis and Evaluation, Conduct of Technical Assessment, Estimate potential for improvement, Establish Goals)

Unit 2:

Energy Audit: Objectives of Energy Management – Energy Audit Types – Audit Methodology – Steps in Energy Audit – Energy Costs – Benchmarking and Energy Performance – Matching energy Usage to Requirement – Maximizing System Efficiency – Energy index – Cost index - Energy Audit Instruments.

Unit 3:

Energy Conservation: List of Energy Intensive Industries - Sankey diagram – Material and Energy balance – Energy Conservation - Rules for Efficient Conservation of Materials and Energy - Identification of Energy Conservation opportunities - Technologies or Approach for Energy Conservation – Energy Conservation Schemes and Measures - Energy flow networks - Critical assessment of energy use - Optimizing Energy Inputs and Energy Balance - Pinch Technology – Energy Conservation in compressed air, Cooling Tower and Refrigeration systems.

Unit 4:

Energy Monitoring and Targeting: Defining monitoring and targeting system – Elements of monitoring and targeting – Data and Information analysis, Techniques – Energy Consumption, Production, Cumulative sum of differences (CUSUM). Global Environmental Concerns: Climate Change Problem and Response – Conference of Parties – Prototype Carbon Fund.

Unit 5:

Financial Management: Investment need, Appraisal and Criteria – Financial analysis – Financial Techniques (Simple Payback period, Return on Investment, Net Present Value, Internal Rate of Return), Cash Flow Diagrams.

COURSE OUTCOMES

Student will get

1. An exposure to Energy Consumption pattern resulting in energy savings and conservation.

Text Book:

1. Energy Management and Conservation, K V Sharma and P Venkataseshaiah
2. T_5053_General_Aspects_Of_Energy_Management_And_Energy_Audit (1)

References Books:

1. Energy Conservation, Paul O' Callaghan, 1981.
2. Energy Management, Paul O' Callaghan, McGraw Hill, 1992
3. Energy Management Principles, Craig B. Smith, Pergamon Press
4. Generation, Distribution & Utilization of Electrical Energy, CL Wadhwa, Wiley Eastern Ltd.
5. Energy Management and good lighting practice: Fuel Efficiency Booklet 12 / EEO.

APPLIED THERMODYNAMICS
(Program Elective - II)

M.Tech, ES. I-Sem

L	T	P	C
3	0	0	3

Teaching scheme
Lecture: - 3 h/week

Course Code **1ES12**
Course Name **APPLIED THERMODYNAMICS**

Course objective:

- To predict the condition of systems and analyze them by the criteria of equilibrium.
- To apply the concepts of advanced thermodynamics to combustion systems and refrigeration systems.

LECTURE WITH BREAKUP

Unit 1:

Introduction: Thermodynamic system - types – properties – Zeroth Law of Thermodynamics – Measurement of Temperature - Work Transfer and Heat Transfer – First Law of Thermodynamics applied to Closed and Open Systems - Second Law of thermodynamics – Concept of entropy – Clausius inequality – Available energy - Availability – Irreversibility.

Unit 2:

Properties of Perfect Gases: Laws of Perfect gases – Boyle's Law – Charles Law – Gay Lussac Law – General gas equation – Joule's law – Characteristic equation of gas – Avagadro's law – Universal gas constant – Specific heat of a gas – Specific heat and constant volume and pressure – Enthalpy of a gas – Relation between specific heats.

Unit 3:

Gas Power Cycles: Carnot cycle - Air standard assumptions - Otto cycle - Diesel cycle – Dual cycle – Stirling cycle – Ericsson cycle – Brayton cycle – Brayton cycle with Inter cooling, Reheating and Regeneration.

Unit 4:

Vapor Power Cycles (Elementary treatment only): Carnot vapor cycle – Ideal Rankine cycle – Deviation of Actual Vapor power cycle from Ideal cycle – Actual Rankine cycle – Methods to increase efficiency of Rankine cycle (Lowering of condenser pressure - Super heating steam to High temperature - Increasing Boiler pressure) – Reheat and Regenerative Rankine cycle.

Unit 5:

Psychometry & Air Conditioning: Dry and atmospheric air – Specific and relative humidity of air – Dew point temperature – Adiabatic saturation and wet bulb temperature – The psychometric chart – Human comfort and air conditioning.

Refrigeration cycles: Applications – air refrigeration – vapour compression refrigeration – effects of operating parameters – COP – vapour absorption refrigeration system.

Converters and Energy Storage Devices: Fundamentals of convertors - Thermo-electric-MHD - basics of energy storage devices – Thermo-chemical energy storage – Sensible and Latent heat storage – Chemical Energy Storage – Electromagnetic energy storage - Working – governing - parameters.

COURSE OUTCOMES

Students will

1. Analyze the engineering systems to improve and optimize its performance
2. Understand the working and the design principles of combustion systems and refrigeration systems.

Text Book:

1. Thermodynamics – An Engineering Approach , Y.A.Cengel and Mc. A. Boles.
2. Basic and Applied Thermodynamics, P.K.Nag, Tata Mcgraw Hill

Reference Books:

1. Thermodynamics / Sontag & Van Wylen
2. Thermodynamics / YVC RAO.
3. Introduction to the Thermodynamics of Materials – David R. Gaskell

ENVIRONMENTAL POLLUTION AND CONTROL
(Program Elective - II)

M.Tech, ES. I-Sem **L T P C**
3 0 0 3

Teaching scheme
Lecture: - 3 h/week

Course Code **1ES12**
Course Name **ENVIRONMENTAL POLLUTION AND CONTROL**

Course objective:
- To understand the concepts of pollution/pollutants and its impact on the environment.

LECTURE WITH BREAKUP
Unit 1:
Overview of Environmental Concepts: Global Warming - Ozone Layer & UV Radiations - Deforestation - Energy & Matter Cycles - Case Studies of Significant Environmental Problems and Disasters and the lessons learnt. Influence of pollution regionally and globally.

Unit 2:
Air Pollution: Natural and anthropogenic sources of pollution - Primary and Secondary pollutants - Transport and diffusion of pollutants - Gas laws governing the behavior of pollutants in the atmosphere - air sampling methods.

UNIT 3:
Air Pollution Control: Methods of monitoring and control of air pollutants $S0_2$ NO_2, CO, SPM - Effect of pollutants on human beings – Plants – Animals - Materials and on climate - Acid Rain - Ambient Air Quality Standards - Air pollution control methods and equipment.

Unit 4:
Solid Waste: Sources and classification of land pollutants - Industrial waste effluents and heavy metals - Their interactions with soil components - Degradation of different insecticides - Fungicides and weedicides in soil - Solid waste management - Process and equipment for energy recovery from municipal solid waste and industrial waste - MSW Act 2000.

Unit 5:
Water Pollution: Types - Sources and consequences of water pollution – Physical - chemical and Bacteriological sampling and analysis of water quality – Standards - Sewage and waste water treatment and recycling ASP/STP - Water quality standard – Treatment - Utilization and disposal of sludge - Government norms.

COURSE OUTCOMES
Student will be able to
1. Have knowledge of continual degradation of environment due to pollutants.
2. Have an exposure to different types of pollution control methods.

Text Book:
1. Environmental Pollution Control Engineering, C. S. Rao, Wiley Eastern Ltd., Delhi 1991.

Reference Books:

1. Management of Energy Environment Systems, W.K.Foell, John Wiley and Sons.
2. Energy Management and Control Systems, M.C.Macedo, Jr. John Wiley and Sons.
3. Environmental Impact Analysis Handbook, J.G.Rau, D.C.Wood, Mc Graw Hill.
4. Energy & Environment, J.M. Fowler, Mc Graw Hill.

RESEARCH METHODOLOGY AND IPR

M.Tech, ES. I-Sem

L	T	P	C
2	0	0	2

Teaching scheme
Lecture: - 3 h/week

Course Code **1A111**
Course Name **RESEARCH METHODOLOGY AND IPR**

Course objectives:

- To have knowledge of process for undertaking research.
- To get an exposure to different research experiences.

LECTURE WITH BREAKUP

Unit1:

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 2:

Effective literature studies approaches, analysis Plagiarism, Research ethics.

Unit 3:

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 4:

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 5:

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

Unit 6:

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.

COURSE OUTCOMES

Students will be able to

1. Understand research problem formulation.
2. Analyze research related information
3. Follow research ethics
4. Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
5. Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Model Curriculum of Engineering & Technology PG Courses [Volume-I] [16] Intellectual Property Right to be promoted among students in general & engineering in particular.
6. 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.

Reference Books:

1. Research methodology: an introduction for science & engineering students, Stuart Melville and Wayne Goddard
2. Research Methodology: An Introduction, Wayne Goddard and Stuart Melville,
3. Research Methodology: A Step by Step Guide for beginners, Ranjit Kumar, 2nd Edition,
4. Resisting Intellectual Property, Halbert, Taylor & Francis Ltd, 2007.
5. Industrial Design, Mayall McGraw Hill, 1992.
6. Product Design, Niebel , McGraw Hill, 1974.
7. Introduction to Design, Asimov Prentice Hall, 1962.
8. Intellectual Property in New Technological Age, Robert P. Merges, Peter S. Menell, Mark A. Lemley, 2016.
9. Intellectual Property Rights Under WTO, T. Ramappa, S. Chand, 2008

ENGLISH FOR RESEARCH PAPER WRITING
(Audit Course)

M.Tech, ES. I-Sem

L	T	P	C
2	0	0	0

Teaching scheme
Lecture: - 3 h/week

Course Code **1A112**
Course Name **ENGLISH FOR RESEARCH PAPER WRITING**

Course objective
Students will be able to:

- Understand that how to improve your writing skills and level of readability
- Learn about what to write in each section
- Understand the skills needed when writing a Title
- Ensure the good quality of paper at very first-time submission

LECTURE WITH BREAKUP

Unit 1:
Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness.

Unit 2:
Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction

Unit 3:
Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.

Unit 4:
Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature.

Unit 5:
Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

Text Books:-

1. Writing for Science, Goldbort R (2006), Yale University Press (available on Google Books)
2. How to Write and Publish a Scientific Paper, Day R (2006), Cambridge University Press.
3. Handbook of Writing for the Mathematical Sciences, Highman N (1998), Highman's book. SIAM.
4. English for Writing Research Papers, Adrian Wallwork , Springer New York Dordrecht Heidelberg London, 2011.

RENEWABLE ENERGY LABORATORY

M.Tech, ES. I-Sem

L	T	P	C
0	0	4	2

Teaching scheme
Lecture: - 3 h/week

Course Code	**1ES03**
Course Name	**RENEWABLE ENERGY LABORATORY**

Course objective:

- To determine the efficiency of various renewable energy systems.

LECTURE WITH BREAKUP
Study of

1. Operational experience on i) Pyranometer, ii) Sunshine recorder.
2. Measurement of speed using Tachometer, Stroboscope and anemometers.

List of experiments

1. Performance evaluation of a solar Flat Plate Thermosyphon water heating system.
2. Conversion efficiency of a solar Flat Plate Forced Circulation water heating system.
3. Conversion efficiency of a solar Evacuated Tube water heating system.
4. Determination of conversion efficiency of a solar Air Heating system.
5. Performance estimation of photovoltaic water pumping system.
6. Estimation of moisture removal from a solar dryer.
7. Determination of characteristics of a wind generator.
8. Performance evaluation of solar cooker.
9. Performance evaluation of horizontal axes wind turbine.
10. Study and analysis of a solar still / distillation plant.

ENERGY COMPUTATIONAL LABORATORY

M.Tech, ES. I-Sem

L	T	P	C
0	0	4	2

Teaching scheme
Lecture: - 3 h/week

Course Code	**1ES04**
Course Name	**ENERGY COMPUTATIONAL LABORATORY**

Course objective

1. To expose to programming language, C / Fortran
2. To solve problems in renewable energy conversion technologies

1. Fundamentals of C Programming
2. Applications of C programming in the following areas:
   Problems related to Renewable Energy Sources: Solar and Wind
   Problems related to Heat transfer
   Problems related to Linear Control Systems
3. Use of Origin Lab – Data Analysis and Graphing Software

COURSE OUTCOMES

Student get

1. Exposure to C programming
2. Expertise in developing programs in various applications.

DIRECT ENERGY CONVERSION

M.Tech, ES. II-Sem

L	T	P	C
3	0	0	3

Teaching scheme
Lecture: - 3 h/week

Course Code **2ES05**
Course Name **DIRECT ENERGY CONVERSION**

Course objective:
To analyze the working principle, pros and cons of

- Conventional energy conversion techniques
- Direct energy conversion systems
- Need and necessity of integration of different energy systems with grid.

LECTURE WITH BREAKUP

Unit1:

Photovoltaic Fundamentals: Place of PV in energy supply – PV Cells, Modules and arrays, & costs, Review of semiconductor physics and Operating principle-–Introduction to P-N and P-I-N junctions - Equilibrium and non-equilibrium conditions-Design of solar cells: Cell parameters limits-Losses in solar cells-Solar cell design for high $I_{sc,}$, V_{oc} and FF.

Unit 2:

Solar cell technologies: Silicon based technologies (mono-crystalline, poly-crystalline, ribbon, silicon film), Flow of silicon material, Manufacturing processes (wafer, cell and module) for Mono and poly Si technologies, Efficiency of Si cells; Thin film technologies (Silicon and Non-silicon): Material-deposition techniques, Amorphous Si cells/modules, micro-morph cell, Silicon film- Non-silicon technologies viz Cadmium telluride, Cu Indium Gallium Diselenide. Concept of multi-junction or tandem cells, concentrating technologies-Optics for concentrators - PV-Tracking requirements-High concentrator solar cells-Emerging solar cell technologies (Organic PV, Heterojunction with intrinsic thin film, HIT, Quantum dots, Dye Sensitized Solar cell, Peroskvite solar cells etc).

Unit 3:

PV module and PV System applications: Solar PV modules-Mismatch in series and parallel connection-design & structure of PV modules-PV module power output-Batteries for PV systems-DC to DC and DC to AC converters-charge controllers-MPPT; Standalone PV systems-Design methodology of PV off grid and grid connected systems- Load estimation and System Sizing, Wire sizing in PV systems-Grid connected and hybrid PV systems. Design of roof top solar PV power plants (typically 100 kWp), Flowchart for design of solar PV power plants.

Unit 5:

Integration of renewable energy sources: Overview of challenges in integrating renewable sources to the grid - Need to maintain voltage within a band and fluctuations in voltage because of renewable integration - Power inverter and converter technologies - Mechanism to synchronize power from renewable sources to the grid - Overview of challenges faced in designing power injection from offshore generation sources.

COURSE OUTCOMES

Students get

1. Awareness on the existence of various mechanisms for conversion of energy,
2. Exposure to merits, constraints and drawbacks

Text Books:

1. Energy Conversion, Mechanical Engineering Handbook, "D. Yogi Goswami"
2. Solar Energy - Principles of thermal collection and storage, S. P. Sukhatme

Reference Books:

1. "Energy Conversion", Lawrence Conway, Westinghouse Electric Corporation
2. "Microgrids and Active Distribution Networks", S. Chowdhury, S.P. Chowdhury, P. Crossley, Institution of Engineering and Technology, 30 Jun 2009.

ENERGY EFFICIENCY IN THERMAL SYSTEMS

M.Tech, ES. II-Sem

L	T	P	C
3	0	0	3

Teaching scheme
Lecture: - 3 h/week

Course Code **2ES06**
Course Name **ENERGY EFFICIENCY IN THERMAL SYSTEMS**

Course objective:

- To understand the concepts of energy conversion in thermal utilities and estimate the performance.

LECTURE WITH BREAKUP

Unit1:

Fuels and Combustion: Properties of Solid, liquid and gaseous fuels – Combustion analysis – Draft – Combustion control.
Boilers – Performance Evaluation – Indirect Method - Boiler water Treatment – Energy Conservation Opportunities.

Unit 2:

Furnaces: Classification – Performance Evaluation – Indirect Method of Evaluation - Fuel Economy Measures (Air Preheater – Heat losses and Prevention).
Insulation and Refractories: Insulation – Types and Applications – Economic Thickness of Insulation – Heat Savings and Application Criteria – Refractories – Selection of Refractories

Unit 3:

FBC Boilers: Mechanism of Fluidized Bed – Advantages – Types of FBC Boilers – Operational Features – Saving Potential. Fans and Blowers: Performance evaluation – Efficient System Operation – Fan Performance Assessment. Energy Saving Opportunities.

Unit 4:

Pumps and Pumping System: Classification of Pumps – System Characteristics – Factors affecting pump performance – Efficient pumping system operation – Flow Control Strategies – Energy Conservation Opportunities.

Unit 5:

Cogeneration: Definition – Basic Thermodynamic Cycles – Classification of Cogeneration Systems. Waste Heat Recovery Systems: General Classification – Benefits of Waste heat Recovery – Waste Heat Recovery Devices (Recuperator, Regenerators, Heat Wheels, Heat Pipe, Economizers, Heat Pump).

COURSE OUTCOMES

Student will be able to
1. Have knowledge of equipment used in thermal power plants.
2. Estimate the conversion efficiency of the components.

Text Books:

1. T_5119_Energy_Efficiency_In_Thermal_Utilities Book 2.
2. T_5121_Energy_Performance_Assessment_For_Equipment_And_Utility_Systems_Book 4.

Reference Books:

1. Analysis of Engineering Cycles, R. W. Haywood, 4th Edition, Pergamon Press, Oxford, 1991.
2. Boiler Control Systems, D. Lindsay, Mcgraw Hill International, London, 1992.
3. Least Cost Electrical Utility / Planning, H. G. Stoll, John Wiley & Sons, 1989.
4. Short Term Forecasting: An introduction to the Box Jenkins Approach, T. M. O` Donovan, Wiley, Chichester, 1983.
5. Industrial Energy Management and Utilization, 1988, LC Wittie, P S Schmidt and D R Brown, Hemisphere Publishing Company.

ENERGY EFFICIENCY IN ELECTRICAL UTILITIES
(Program Elective - III)

M.Tech, ES. II-Sem **L T P C**
3 0 0 3

Teaching scheme
Lecture: - 3 h/week

Course Code	**2ES13**
Course Name	**ENERGY EFFICIENCY IN ELECTRICAL UTILITIES**

Course objectives:

- To have basic concepts of Electrical systems, motors, lighting systems.
- To apply Electrical systems for Power Factor improvement.
- To illustrate the application of different electrical systems in improving energy efficiency.

LECTURE WITH BREAKUP

Unit1:

Electrical Systems: Electrical Power Supply Systems – Electricity Billing – Load Management and Maximum demand control – Power factor improvement and its benefits – Selection and location of capacitors – Performance assessment of PF capacitors Transformers – System Distribution Losses.

Unit 2:

Analysis of Power Systems: Analysis of System load curve -plant load factor, availability, Loss of load Probability calculations for a power system, Maintenance Scheduling - Pricing of Power - Project cost components, Analysis of Power Purchase Agreements (PPA), Debt/Equity Ratio and effect on Return on Investment, Environmental Legislations/Government Policies - Optimal Dispatch - Scheduling of Hydro-Thermal plants, Load Forecasting - Time series, Econometric, end use techniques. Least Cost Power Planning.

Unit 3:

Electric Motors: Motor Types – Motor Characteristics – Motor Efficiency – Selection of Motors – Energy Efficient Motors – Factors affecting Energy Efficiency – Minimization of Motor Losses in Operation – Rewinding effects on Energy Efficiency – Speed control of AC induction Motors – Motor Load Survey: Methodology.

Unit 4:

Lighting System: Basic terms in lighting system and their features – Lamp types and their features – Recommended illuminance levels – Methodology of lighting systems – Case studies – Good practices in lighting system.

DG Set System: Introduction – Selection and Installation factors – Operational factors – Energy performance assessment of DG sets – Energy Saving measures for DG sets.

Unit 5:

Energy Efficiency Technologies: Maximum demand controllers – Automatic Power factor controllers – Energy efficient motors – Soft starters – Variable speed drives – Performance terms and definitions – Efficiency testing – Determining Motor Loading – Performance evaluation of Rewound motors – Application of Variable Speed Drives - Energy efficient transformers – Electronic ballasts – Energy efficient lighting controllers.

COURSE OUTCOMES

Student will be able to

1. Understand the concepts of improvement of power factor of an Electrical system and lighting system.
2. Understand the implementation of Energy Efficient Technologies in Electrical Systems.

Textbooks:

1. Energy Efficiency for Engineers and Technologists, Eastop T.D & Croft D.R, Logman Scientific & Technical, ISBN-0-582-03184, 1990.
2. Industrial Energy Conservation, Reay D.A, 1st edition, Pergamon Press, 1977.

Reference Books:

1. Power Plant Engineering, P.K.Nag / Tata McGraw Hill.
2. Power Plant Performance, A. B. Gill, Butterworths, 1984.
3. Power Generation, operation & control, A. J. Wood and B. F. Wollenberg, John Wiley, New York, 1984.
4. Power System Engineering, 2nd Ed. D P Kothari, I J Nagrath, Tata McGraw-Hill Co 2008
5. The Energy and Resource Institute (TERI): http://www.teriin.org/
6. Energy Efficiency for Engineers and Technologists, First Edition, 1990, by TD Eastop and DR Croft, Longman Group UK Ltd.
7. Bureau of Energy Efficiency (BEE): www.beeindia. gov.in/content/energy-auditors.

NUCLEAR POWER PLANTS
(Program Elective – III)

M.Tech., ES. II-Sem

L	T	P	C
3	0	0	3

Teaching scheme
Lecture: - 3 h/week

Course Code **2ES13**
Course Name **NUCLEAR POWER PLANT**

Course objective:

- To understand the concepts of pollution/pollutants and how to protect it from the environment.

LECTURE WITH BREAKUP

Unit 1:

NUCLEAR FUEL AND REACTOR THEORY: Nuclear fuels-occurrence and extraction, fissile characteristics, enrichment, fission process - thermal and fast fission - energy released from fission - chain reaction - reaction control.
Neutron balance - fast fission - resonance capture – thermalization - geometric effects - burn-up – introduction to reactor kinetics.

Unit 2:

REACTOR COMPONENTS: General components of nuclear reactor - Fuel cladding - fuel assembly – moderators – coolants - control rods - Reactor safety - Neutron Population growth - assurance of safety - emergency core cooling and containment.

Unit 3:

REACTOR TYPES: Different types of reactors - Pressurized Water Reactor - Boiling Water Reactor - Heavy Water-cooled Reactor -Gas cooled Reactor - Liquid metal cooled reactor - Organic moderated and cooled reactors - Fast Breeder Reactors – Fifth generation reactors.

Unit 4:

RADIOACTIVE WASTE MANAGEMENT: The nuclear fuel cycle - Waste classification - Spent fuel storage – Transportation – Reprocessing - High-Level waste disposal - low-level waste generation and treatment - Low-level waste disposal - Nuclear power plant decommissioning.

Unit 5:

NUCLEAR POWER FOR PROPULSION AND ENERGY ECONOMICS: Reactors for naval propulsion - Space reactors - Space isotopic power generator - Energy economics -Components of electrical power – Cost forecast versus Reality - Challenges and opportunities - Technical and institutional improvements – Developments in nuclear reactor.

COURSE OUTCOMES

Student will be able to

1. Have knowledge of continual degradation of environment.
2. Have an exposure to different types of pollutions control methods.

Text Book:

1. Principle of Energy Conversion, Archie W.Culp, McGraw Hill, Kogakusha Ltd., 1984.

Reference Books:

1. Nuclear Power Technology, W. Marshall, Vol. I &II, Clarendon press, Oxford, 1985.
2. Principle of Nuclear Reactor Engineering, Samual Glasstone, Van Nostrand Reinhold Co. Inc., New York, 1963.
3. A course in Power Plant Engineering, Arora and Domkundwar, Dhanpat Rai.
4. Power Plant Technology, El Wakil/ Mc Graw Hill.
5. Power Plant Engineering, G.R. Nagpal/Khanna Publishers.
6. Power Plant Technology, Rajput.

MEASUREMENTS IN ENERGY ENGINEERING
(Program Elective - III)

M.Tech, ES. II-Sem

L	T	P	C
3	0	0	3

Teaching scheme
Lecture: - 3 h/week

Course Code **2ES13**
Course Name **MEASUREMENTS IN ENERGY ENGINEERING**

Course objectives:

- To study the characteristics of instruments.
- To analyse various types of transducers based on the principle of operation and construction.
- To understand about various measuring devices and their calibration.

LECTURE WITH BREAKUP

Unit1:

Elements of a Measurement System: Basic Instrumentation system – Classification of instruments - Errors and Uncertainties in measurement.

Electrical transducers : Resistive Transducers - Inductive Transducers – Capacitive transducers - Thermoelectric Transducers and Photoelectric Transducers - Piezoelectric Transducers.

Unit 2:

Basic Signal Conditioning Elements: Amplifiers- Non Electrical and Electrical types - Op Amps- Summing, Differential, and Charge Amplifiers - Differentiating and Integrating Elements – Filters – A to D and D to A Converters - Data Transmission Elements- Electrical, Pneumatic, Position and Radio Frequency Transmission types.

Unit 3:

Industrial Measurements:

Velocity Measurement: Contact type - AC-DC Tachometers Non-contact type - Magnetic, Photoelectric & stroboscopic methods.

Acceleration measurement: Seismic Accelerometer & Piezoelectric Accelerometer.

Measurement of Radiation: Radiation Fundamentals - Radiation detectors - Optical pyrometer.

Unit 4:

Mechanical Transducers:

Measurement of Temperature: Bimetallic Element and Fluid Expansion type Thermometers.

Measurement of Pressure: Manometers and Bourdon Gauges - Load Cells and Elastic Force Devices.

Measurement of Force: Different methods - Strain gauge load cell method.

Measurement of torque: Strain gauge method.

Unit 5:

Feedback in Instruments: Principles of Feedback - Advantages & Disadvantages of Feedback

Digital Voltmeters: Ramp and Dual Slope types – Servo type Potentiometric and Magnetic tape Recorders – Digital Recorders of Memory type.

Data displays: Analog and Digital types.

OURSE OUTCOMES
Student will be able to
1. Select the transducer and their types, usage and operation and different characteristics of transducers.
2. Calibrate the various instruments and apply to different instruments in the field.

Text Books:

1. Modern Electronic Instrumentation and Measurement Techniques; Albert D Helfrick and William D Cooper; 2004, PHI.

Reference Books:

1. Instrumentation, Measurement and Analysis; BC Nakra, and KK Chaudhry, 2 ed, 2004, Tata McGraw-Hill
2. Transducers and Instrumentation; DVS Murthy, 2003, PHI
3. Instrumentation Devices and Systems, CS Rangan, GR Sarma, and VSV Mani, 2nd Ed, Tata McGraw-Hill
4. Measurement Systems Application and Design; Doeblin and Ernest; 5th Ed, 2004, Tata McGraw-Hill.
5. Measurement Systems – Applications & design, Doeblin E.O. 4th Ed. Mc. Graw Hill
6. Principles of Industrial Instrumentation, Patranabis D. ,Tata McGraw Hill – 1997.
7. Mechanical & Industrial Measurements, Jain R.K, Khanna Publishers – 1986.

OPTIMIZATION OF ENERGY SYSTEMS
(Program Elective – IV)

M.Tech, ES. II-Sem

L	T	P	C
3	0	0	3

Teaching scheme
Lecture: - 3 h/week

Course Code **2ES14**
Course Name **OPTIMIZATION OF ENERGY SYSTEMS**

Course objective:

- To have a knowledge of optimisation of design parameters.
- To have an exposure to different design methodologies and simulation processes.

LECTURE WITH BREAKUP

Unit1:

Thermal Systems – Characteristics- formulation of design problem - Steps in the design process - Modeling of thermal systems – importance - Types of models - Mathematical Modeling

Unit 2:

Linear programming models – Formulation - Simplex method – Artificial variable technique – Big M method - Concept of Sensitive analysis.

Unit 3:

Unconstrained Optimization: Single variable optimization – Fibonacci & Golden section method - Multi variable optimization – Gradient methods – Gradient of the function - Steepest descent – Flecher-Reeves method -Variable metric method - Constrained Non-linear Optimization Methods - Lagrangian multiplier – Application to thermal and electrical systems.

Unit 4:

Geometric programming – Polynomial – Arithmetic and Geometric inequalities – Unconstrained GP - Constrained GP with constraints of type less than or equal- Application to thermal and electrical systems- Dynamic Programming- Bellman's principle of optimality- Shortest route problems

Unit 5:

Simulation - Definition- Types of Simulation models - Steps involved in simulation models - Application of simulation - Advantages and disadvantages – Introduction to Genetic algorithm – Applications in Genetic Algorithm - Similarities and dissimilarities with traditional methods - Genetic operators.

COURSE OUTCOMES

Students have an exposure to

1. Numerical calculations
2. Role of design parameters
3. Simulation models like genetic algorithms

Text Books:

1. Design and Optimization of Thermal Systems, Yogesh Jaluria, McGraw Hill.
2. Optimization theory and applications, S.S.Rao, New Age Publication.

Reference Books:

1. Design of Thermal System, W.F.Stoecker, McGraw Hill.
2. Operation Research, Panner Selvam, Prentice Hall.
3. Optimization Research, M.C.Joshi.
4. Simulation Modeling & Analysis, Law & Kelto.
5. Operation Research, S Prinsc Valle Kasur.

WIND ENERGY CONVERSION SYSTEMS
(Program Elective-IV)

M.Tech, ES. II-Sem

L	T	P	C
3	0	0	3

Teaching scheme
Lecture: - 3 h/week

Course Code **2ES14**
Course Name **WIND ENERGY CONVERSION SYSTEMS**

Course objectives:

- To understand the fundamentals of wind energy and its conversion system
- To learn gear coupled generator wind turbine components
- To learn modern wind turbine control & monitoring.

LECTURE WITH BREAKUP

Unit1:

Wind Energy Fundamentals & Wind Measurements:

Wind Energy Basics, Wind Speeds and scales, Terrain, Roughness, Wind Mechanics, Power Content, Class of wind turbines, Atmospheric Boundary Layers, Turbulence. Instrumentation for wind measurements, Wind data analysis, tabulation, Wind resource estimation, Betz's Limit, Turbulence Analysis.

Unit 2:

Aerodynamics Theory & Wind Turbine Types:

Airfoil terminology, Blade element theory, Blade design, Rotor performance and dynamics, Balancing technique (Rotor & Blade), Types of loads; Sources of loads Vertical Axis Type, Horizontal Axis, Constant Speed Constant Frequency, Variable speed Variable Frequency, Up Wind, Down Wind, Stall Control, Pitch Control, Gear Coupled Generator type, Direct Generator Drive /PMG/Rotor Excited Sync Generator.

Unit 3:

Gear Coupled Generator Wind Turbine Components And Their Construction:

Electronics Sensors/Encoder/Resolvers, Wind Measurement : Anemometer & Wind Vane, Grid Synchronisation System, Soft Starter, Switchgear[ACB/VCB], Transformer, Cables and assembly, Compensation Panel, Programmable Logic Control, UPS, Yaw & Pitch System : AC Drives, Safety Chain Circuits, Generator Rotor Resistor controller (Flexi Slip), Differential Protection Relay for Generator, Battery/Super Capacitor Charger & Batteries/ Super Capacitor for Pitch System, Transient Suppressor/Lightning Arrestors, Oscillation & Vibration sensing.

Unit 4:

Direct Rotor Coupled Generator (Multipole) [Variable Speed Variable Freq.]:

Excited Rotor Synch, Generator/PMG Generator, Control Rectifier, Capacitor Banks, Step Up/Boost Converter (DC-DC Step Up), Grid Tied Inverter, Power Management, Grid Monitoring Unit (Voltage and Current), Transformer, Safety Chain Circuits

Unit 5:

Modern Wind Turbine Control & Monitoring System:

Details of Pitch System & Control Algorithms, Protections used & Safety Consideration in Wind turbines, Wind Turbine Monitoring with Error codes, SCADA & Databases: Remote Monitoring and Generation Reports, Operation & Maintenance for Product Life Cycle, Balancing technique (Rotor & Blade), FACTS control & LVRT & New trends for new Grid Codes.

COURSE OUTCOMES

Student will be able to:

1. Know the energy conversion techniques in wind energy
2. Learn about wind turbine components and their constructions.
3. Understand the modern wind turbine control & monitoring.

Text Books:

1. Renewable Energy Sources, Twidell J.W. and Weir A., EFN Spon Ltd., 1983.
2. Renewable Energy, Power for a Sustainable Future, Godfrey Boyle Oxford University Press, 1996.

References Books:

1. C-Wet: Wind Energy Resources Survey in India VI.
2 Solar Engineering of Thermal Processes, Duffie A. and Beckmann W. A., John Wiley, 1991.
3. Wind Energy Conversion Systems, Freris L.L., Prentice Hall, 1990.
4. Wind Energy Systems, John D Sorensen and Jens N Sorensen, Woodhead Publishing Ltd, 2011.
5. Stand – alone and Hybrid Wind Energy Systems, Kaldellis J.K., CRC Press, 2010.
6. Wind Energy Systems, Mario Garcia –Sanz, Constantine H. Houpis, CRC Press 2012.
7. Wind Turbine Technology: Fundamental concepts of Wind Turbine Engineering, Spera D.A., ASME Press, 1994.

SOLAR THERMAL PROCESSES
(Program Elective-IV)

M.Tech, ES. II-Sem

L	T	P	C
3	0	0	3

Teaching scheme
Lecture: - 3 h/week

Course Code **2ES14**
Course Name **SOLAR THERMAL PROCESSES**

Course objectives:

- To clarify impression of various solar thermal energy collectors
- To delineate the other applications and the devices used to collect solar energy
- To summarize the basic economics of solar energy collection system

LECTURE WITH BREAKUP

Unit1:

Solar Collectors: Flat plate - Evacuated tube – Concentrated - Pool and Air collectors Construction – Function - Suitability – Comparison - Storage Tank - Solar Fluids

Unit 2:

Solar Water Heating Systems: Integral Collector Storage System - Thermosyphon System - Open Loop, Drain Down, Drain Back, Antifreeze Systems - Refrigerant Solar Water Heaters - Solar Heated Pools - Solar Heated Hot Tubs and Spas.

Unit 3:

Solar Space Conditioning Systems: Liquid Type Solar Heating System With / Without Storage - Heat Storage Configurations - Heat Delivery Methods - Air-Type Solar Heating Systems - Solar Refrigeration and Air Conditioning.

Unit 4:

Other Solar Applications: Solar Cooking – Distillation - Desalination - Solar Ponds – Solar Passive Architecture – Solar Drying – Solar Chimney.

Unit 5:

Solar Economics : Application of economic methods to analyze the feasibility of solar systems to decide project / policy alternatives - Net energy analysis - and cost requirements for active and passive heating and cooling - for electric power generation - and for industrial process-heating.

COURSE OUTCOMES

1. The impression of various solar thermal energy collectors were clarified.
2. The other applications and the devices used to collect solar energy were incorporated.
3. The basic economics of solar energy collection system was understood.

Text Books:

1. Physics and Technology of Solar Energy- Volume I: Solar Thermal Applications, H P Garg, M Dayal, G Furlan,Springer, 2007.
2. Solar Energy: Principles Of Thermal Collection And Storage, Sukhatme and Nayak, " Tata McGraw.Hill, 2008.
3. Solar Water Heating, Bob Ramlow & Benjamin Nusz, New Society Publishing, 2006.

References Books:

1. Solar Thermal Energy, John Canivan,Sunny Future Press - 2003.
2. "Concentrated Solar Thermal Energy, Charles Christopher Newton, Published by VDM Verlag, 2008.
3. Solar Thermal Energy Storage, H.P.Garg, S.C.Mullick, A.K.Bhargava, D.Reidal, Springer, 2005.
4. Solar Energy Houses: Strategies, Technologies Examples, Anne Grete Hestnes, Robert Hastings, Bjarne Saxhof, Earthscan Publications, 2003.

VALUE EDUCATION
(Audit Course)

M.Tech, ES. II-Sem

L	T	P	C
2	0	0	0

Teaching scheme
Lecture: - 3 h/week

Course Code	**2A113**
Course Name	**VALUE EDUCATION**

Course objectives:
Students will be able to

- Understand value of education and self- development
- Imbibe good values in students
- 3. Let the should know about the importance of character

LECTURE WITH BREAKUP

Unit 1: Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism. Moral and non- moral valuation. Standards and principles. Value judgements

Unit 2: Importance of cultivation of values. Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. Honesty, Humanity. Power of faith, National Unity. Patriotism. Love for nature Discipline

Thinking. Free from anger, Dignity of labour. Universal brotherhood and religious tolerance. True friendship. Happiness Vs suffering, love for truth. Aware of self-destructive habits. Association and Cooperation. Doing best for saving nature

Unit 4: Character and Competence –Holy books vs Blind faith.
Self-management and Good health. Science of reincarnation.
Equality, Nonviolence, Humility, Role of Women. All religions and same message. Mind your Mind, Self-control. Honesty, Studying effectively

COURSE OUTCOMES
Students will be able to

1. Knowledge of self-development.
2. Learn the importance of Human values.
3. Developing the overall person.

Text Books:-

1. Values and Ethics for organizations Theory and practice, Chakroborty, S.K. Oxford University Press, New Delhi.

ENERGY CONVERSION LAB

M.Tech, ES. II-Sem

L	T	P	C
0	0	4	2

Teaching scheme
Lecture: - 3 h/week

Course Code **2ES07**
Course Name **ENERGY CONVERSION LABORATORY**

Course objective:

- To have knowledge of energy conversion principles from one to another.

LECTURE WITH BREAKUP

Study of:

1. Measurement of temperature using Infrared Thermometers
2. Measurement of illumination using Lux meter
3. Exhaust gas analysis using gas analyzer

Experiments:

1. Conversion Efficiency of Light energy to Chemical form in Fuel Cell.
2. Conversion of Chemical Energy to electricity generation in Fuel cell.
3. Conversion of light form to electrical energy in Solar Simulator.
4. Conversion efficiency of electrical energy to heat by Forced Convection.
5. Conversion efficiency of electrical energy to heat by Free Convection in liquids.
6. Influence of different radiation filters on solar cell output.
7. Determination of LUX intensity for various LED lights.
8. Performance Comparison of different solar cells.
9. Conversion Efficiency of P.V. Indoor lighting system.
10. P.V. System sizing exercise.

COMPUTER SIMULATION LAB

M.Tech, ES. II-Sem

L	T	P	C
0	0	4	2

Teaching scheme
Lecture: - 3 h/week

Course Code	**2ES08**
Course Name	**COMPUER SIMULATION LABORATORY**

Course objective

LECTURE WITH BREAKUP

WRITING PROGRAMS AND DEMONSTRATION

1. Declination of earth - hour angle - day length - local apparent time.
2. Monthly average - hourly global and diffuse radiation on a horizontal surface and tilted surfaces.
3. Power generation from a wind turbine - Variation of wind velocity and power with altitude.
4. Solution of ordinary differential eqations-4^{th} order R K Method.
5. Solution of one-dimensional steady state heat conduction equation.
6. Solution of two-dimensional steady state PDE.
7. Solution of one-dimensional transient PDE.

FINITE ELEMENT ANALYSIS

8. Two-dimensional heat conduction
9. One dimensional transient heat conduction
10. Transient analysis of a casting process **CFD ANALYSIS**
11. Flow through a pipe bend
12. Flow through a nozzle

MINI PROJECT WITH SEMINAR

M.Tech, ES. II-Sem

L	T	P	C
2	0	0	2

Teaching scheme
Lecture: - 3 h/week

Course Code	2ES09
Course Name	MINI PROJECT

SMART GRID TECHNOLOGIES
(Program Elective - V)

M.Tech, ES. III-Sem **L T P C**
3 0 0 3

Teaching scheme
Lecture: - 3 h/week

Course Code	**3ES15**
Course Name	**SMART GRID TECHNOLOGIES**

Course objectives:

- To understand concept of smart grid and its developments.
- To understand smart grid technologies and application of smart grid concept in hybrid electric vehicles etc.
- To have Knowledge on smart substations, feeder automation and application for monitoring and protection.
- To have knowledge on micro grids and distributed energy systems.
- To know power quality aspects in smart grid.

LECTURE WITH BREAKUP

Unit 1:

Introduction to Smart Grid: Evolution of electric grid - Concept of smart grid - Definitions – Need of smart grid - Functions of smart grid – Opportunities & barrier of smart grid - Difference between conventional & smart grid - Concept of resilient & self-healing grid - present development & international policies on smart grid – case study of smart grid.

Unit 2:

Smart Grid Technologies-I: Introduction to smart meters- Real time prizing – Smart appliances - Automatic Meter Reading (AMR)- Outage Management Systems (OMS)- Plug In Hybrid Electric Vehicles(PHEV)-Vehicle to grid- Smart sensors- Home & building automation.

Unit 3:

Smart Grid Technologies-II: Smart Substations – Substation automation – Feeder automation – Intelligent Electronic Devices (IED) & their application for monitoring & protection – Smart storage like battery – SMES - Pumped hydro – Compressed air energy storage – Wide Area Measurement System (WAMS) - Phasor Measurement Unit (PMU).

Unit 4:

Micro grids and Distributed Energy Resources: Concept of micro grid- Need & applications of micro grid- Formation of micro grid- Issues of interconnection – Protection & control of micro grid- Plastic & organic solar cells- Thin film solar cells – Variable speed wind generators- Fuel cells- Micro turbines- Captive power plants- Integration of renewable energy sources-Concepts of Islanding.

Unit 5:

Information and Communication Technology for Smart Grid: Advanced Metering Infrastructure (AMI) - Home Area Network (HAN) - Neighbourhood Area Network (NAN) - Wide Area Network (WAN).

COURSE OUTCOMES

Student can:

1. Understand smart grids and analyze grid policies and development in smart grids.
2. Develop concepts of smart grid technologies in hybrid electrical vehicles etc.
3. Understand smart substation, feeder automation, GIS etc.
4. Analyze micro grids and distributed generation systems.
5. Analyze the effect of power quality in smart grid and to understand latest developments in ICT for smart grid.

Text Books:

1. Integration of Green and Renewable Energy in Electric Power Systems, Ali Keyhani, Mohammad N. Marwail, Min Dai Wiley.
2. The Smart Grid: Enabling Energy Efficiency and Demand Response, Clark W. Gellings, CRC Press.
3. Smart Grid: Technology and Applications, Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, Wiley.
4. Smart Grids, Jean Clude Sabonnadiere, Nouredine Hadjsaid, Wiley Blackwell.
5. Smart Power : Climate Changes the Smart Grid, and the Future of Electric Utilities, Peter S. Fox Penner, Island Press; 1 edition 8 Jun 2010.
6. Microgrids and Active Distribution Networks, S. Chowdhury, S.P. Chowdhury, P. Crossley, Institution of Engineering and Technology, 30 Jun 2009.
7. Smart Grids (Power Engineering), Smart Borlase, CRC Press.

Reference Books:

1. The Advanced Smart Grid: Edge Power Driving Sustainability: 1, Andres Carvallo, John Cooper, Artech House Publisher July 2011.
2. Control and Automation of Electric power Distribution Systems (Power Engineering), James Northcote, Green, Robert G. Wilson CRC Press.
3. Substation Automation (Power Electronics and Power Systems), MladenKezunovic, Mark G.Adamiak, Alexander P. Apostolov, Jeffrey George Gilbert Springer.
4. Electrcial Power System Quality, R.C.Durgan, Mark F. McGranghan, Surya Santoso, H. Wayne Beaty, 2nd Edition, McGraw Hill Publication.
5. Communication and Networking in Smart Grids, Yang Xiao, CRC Press.

ENERGY STORAGE SYSTEMS
(Program Elective-V)

M.Tech, ES. III-Sem

L	T	P	C
3	0	0	3

Teaching scheme
Lecture: - 3 h/week
Course Code **3ES15**
Course Name **ENERGY STORAGE SYSTEMS**

Course objectives:

- To understand the concept of understand / analyse the various types of energy storage.
- To study the various applications of energy storage systems

LECTURE WITH BREAKUP

Unit 1:

Necessity of Energy Storage: Types of energy storage – comparison of energy storage technologies – Applications.

Unit 2:

Thermal Storage: Types - Modelling of thermal storage units - Simple water and rock bed storage.

Unit 3:

System Pressurized Water Storage System: Modelling of phase change storage system - Simple units - Packed bed storage units - Modelling using porous medium approach - Use of Transys.

Unit 4:

Fundamental Concepts of Batteries: Measuring of battery performance - Charging and discharging of a battery - Storage density - Energy density - Safety issues - Types of batteries - Lead Acid, Nickel, Cadmium, Zinc Manganese dioxide and modern batteries for example (i) Zinc-Air (ii) Nickel Hydride (iii) Lithium Battery.

Unit 5:

Hybrid Storage Devices: Flywheel - Super capacitors - Principles & Methods – Applications - Compressed air Energy storage - Concept of Hybrid Storage - Applications.

COURSE OUTCOMES

Students will be

1. Able to analyse various types of energy storage devices and perform the selection based on techno economic view point.

Text Books:

1. Solar Energy – Principles of thermal collection and storage, S. P Sukhatme & J. K. Naik. Tata Mc Graw Hill.
2. Thermal Energy Storage Systems and Applications, Ibrahim Dincer and Mark A. Rosen, John Wiley & Sons 2002.

References Books:

1. Solar Engg. Thermal Procession, Buffa & Buckman
2. Non Conventional Energy Sources, G.D. Rai
3. Engg. Technology, S. Rao & D.B Parulkar
4. Electrochemical technologies for energy storage and conversion, Ru-shiliu, Leizhang, Xueliang sun, Wiley publications, 2012
5. Fuel Cells – Principles and Applications, Viswanathan, B and M Aulice Scibioh, Universities Press (2006).
6. Hydrogen and Fuel Cells: A Comprehensive Guide, Rebecca L. and Busby, Penn Well
7. Corporation, Oklahoma (2005).
8. Hydrogen and Fuel Cells: Emerging Technologies and Applications, Bent Sorensen (Sorensen), Elsevier, UK (2005).

HYDROGEN AND FUEL CELLS
(Program Elective-V)

M.Tech, ES. III-Sem

L	T	P	C
3	0	0	3

Teaching scheme
Lecture: - 3 h/week

Course Code **3ES15**
Course Name **HYDROGEN AND FUEL CELLS**

Course objective:

- To introduce to emerging technologies like production and storage of Hydrogen

LECTURE WITH BREAKUP

Unit1:

Hydrogen Energy Economy: Hydrogen Energy Economy – Conception, Present status and a vision – Applications of Hydrogen - Transport application-cars, light trucks, buses - Stationary and Portable-Electronic gadgets.

Unit 2:

Hydrogen and Production Techniques: Hydrogen – Physical and chemical properties, salient characteristics - Production of hydrogen – Steam reforming – Water electrolysis – Gasification and woody biomass conversion – Biological hydrogen production – Photo dissociation – Direct thermal or catalytic splitting of water.

Unit 3:

Hydrogen Storage & Transport: Hydrogen storage options – Compressed gas – Liquid hydrogen – Hydride – Chemical Storage – Comparisons - Transport of Hydrogen - Pipelines, gaseous, liquid and compound materials.

Unit 4:

Fuel Cells: History – Principle - Working - Thermodynamics and kinetics of fuel cell process – Types of fuel cells – AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – Relative merits and demerits - Performance evaluation of fuel cell – Comparison of battery Vs fuel cell – Flow Battery.

Unit 5:

Application Of Fuel Cell: Fuel cell usage for domestic power systems - Large scale power generation – Automobile - Space - Environmental analysis of usage of Hydrogen in Fuel cell - Future trends in fuel cells.

COURSE OUTCOME

Students gets

1. Exposure to different fuel cells in particularly Hydrogen fuel cells

Text Books:

1. Hydrogen and Fuel Cells: A Comprehensive Guide, Rebecca L. and Busby, Penn Well Corporation, Oklahoma (2005).
2. Fuel Cells – Principles and Applications, Viswanathan, B and M Aulice Scibioh, Universities Press (2006).

Reference Books:

1. Hydrogen and Fuel Cells: A Comprehensive Guide, Rebecca L. and Busby, Penn Well Corporation, Oklahoma (2005) **.**
2. Hydrogen and Fuel Cells: Emerging Technologies and Applications, Bent Sorensen (Sørensen), Elsevier, UK (2005) **.**
3. Fuel Cell and Their Applications, Kordesch, K and G.Simader, Wiley-Vch, Germany (1996).
4. Fuel Cells: Theory and Application, Hart, A.B and G.J.Womack, Prentice Hall, NewYork Ltd., London (1989).
5. The Hydrogen Economy, Jeremy Rifkin, Penguin Group, USA (2002).
6. Fuel Cells – Principles and Applications, Viswanathan, B and M Aulice Scibioh, Universities Press (2006).

WASTE TO ENERGY
(Open Elective)

\M.Tech, ES. III-Sem

L	T	P	C
3	0	0	3

Teaching scheme
Lecture: - 3 h/week

Course Code	**3ES02**
Course Name	**WASTE TO ENERGY**

Course objective

1. To discuss the methods of converting waste into energy through biomass conversion

LECTURE WITH BREAKUP

Unit-1:

Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

Unit-2:

Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

Unit-3:

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-4:

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 5:

Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy 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.

Reference Books:

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 McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.