OBJECTIVES:

- To kindle the analyticity of the engineers.
- To develop an appropriate level of mathematical literacy and competency.

INTENDED OUTCOMES:

- The students will gain the knowledge about vector spaces and linear transformations
- The learners can equip themselves in fuzzy logic techniques which are needed for Engineers in physical scenario.

UNIT – I LINEAR SYSTEMS (14)

UNIT - II LINEAR PROGRAMMING (12)
Basic concepts – Graphical and Simplex methods –Transportation problem – Assignment problem.

UNIT - III GRAPH THEORY (12)
Graphs – Path, cycles and trials – Vertex, degree and counting – Connectivity and Paths.

UNIT - IV TREES (10)
Basic properties – Spanning trees and Enumeration – Optimization and trees.

UNIT – V FUZZY LOGIC (10)
Classical logic – Multivalued logics – Fuzzy propositions – Fuzzy Quantifiers.

Total hours: 60

TEXT BOOKS:

<table>
<thead>
<tr>
<th>S. NO.</th>
<th>AUTHOR(S) NAME</th>
<th>TITLE OF THE BOOK</th>
<th>PUBLISHER</th>
<th>YEAR OF PUBLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>George J Klir and Tina A. Folger</td>
<td>Fuzzy sets, Uncertainty and Information</td>
<td>Prentice Hall of India Pvt Ltd., New Delhi.</td>
<td>2007</td>
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<tr>
<td>1</td>
<td>Howard Anton</td>
<td>Elementary Linear Algebra</td>
<td>John Wiley &amp; Sons, New Delhi.</td>
<td>2010</td>
</tr>
<tr>
<td>3</td>
<td>Douglas. B. West</td>
<td>Introduction to Graph theory</td>
<td>Prentice Hall of India Pvt Ltd., New Delhi.</td>
<td>2007</td>
</tr>
</tbody>
</table>

WEBSITES:

1. www.nptel.ac.in
2. www.mathworld.com
3. www.springer.com
15MERE102 ENERGY CONVERSION TECHNOLOGIES  3 1 0 4

OBJECTIVES:

To analyze the working principle, pros and cons of
• Thermal, Electrical and Mechanical Energy systems
• Need and necessity of cogeneration systems and their applications

INTENDED OUTCOMES:

• To understand the existence of various mechanisms for conversion and storage of energy, their merits, constraints and drawbacks.
• To gain the knowledge of cogeneration, integrated energy systems and their applications

UNIT-1 INTRODUCTION  12
Energy sources, classification, fuel supply and demand, energy conversion efficiencies.

UNIT-2 ELECTRICAL ENERGY SYSTEMS  12
Electrical, electro magnetic, chemical and other energy conversion systems and related equipments, MHD, hydrogen, fuel cells, batteries, thermionic and thermoelectric generators, transformers, motors.

UNIT-3 THERMAL ENERGY SYSTEMS  12
Combustion equipments, boilers and types, furnaces, draught control, economizers, super heaters, preheaters, design aspects, fuel and ash handling systems.

UNIT-4 MECHANICAL ENERGY SYSTEMS  12
Mechanical energy conversion, types, hydraulic, steam and gas turbines, pumps, fans, compressors, performance characteristics, evaluation.

UNIT-5 COGENERATION SYSTEMS  12
Application for cogeneration, types of cogeneration processes, topping cycle plant, bottoming cycle plant, economics.

Total Hours = 60 Hours

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<tr>
<td>2</td>
<td>Reay,D.A</td>
<td>Industrial energy conservation</td>
<td>Gamon press</td>
<td>2003</td>
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<tr>
<td>1</td>
<td>Boyce M.P</td>
<td>Cogeneration and combined cycle plants</td>
<td>ASME press</td>
<td>2010</td>
</tr>
<tr>
<td>2</td>
<td>Hamies</td>
<td>Auditing and conservation; methods, measurements, Management and case study</td>
<td>Hemisphere</td>
<td>2003</td>
</tr>
</tbody>
</table>
15MERE103 ENVIRONMENTAL IMPACT OF ENERGY SYSTEMS  3 0 0 3

OBJECTIVES:

- To familiarize the students in the area of environmental impact of energy systems.
- To create awareness among the student community on anthropogenic degradation of environment and technologies available to limit the degradation.

INTENDED OUTCOMES:

- To understand the environmental impacts and degradation due energy production and utilization.
- To understand the causes of different types of pollution and their impact assessment.
- To gain the knowledge of waste management and control.
- To understand the concept of carbon credits for environmental protection.

UNIT I - ENVIRONMENTAL IMPACTS  9
Environmental impacts - Environmental degradation due to energy production and utilization.

UNIT II – POLLUTION  9
Primary and secondary pollution, air, thermal and water pollution, depletion of ozone layer, global warming, biological damage due to environmental degradation. Methods of environmental impact assessment.

UNIT III - POLLUTION FROM POWER PLANTS AND ITS CONTROL  9
Pollution - Pollution due to thermal power station and its control and systems. Pollution due to nuclear power generation, radioactive waste and its disposal, effect of hydro electric power stations on ecology and environment.

UNIT IV - WASTE MANAGEMENT AND POLLUTION CONTROL  9
Waste as a source of energy - Industrial, domestic and solid waste as a source of energy. Pollution control - Causes process and exhaust gases and its control, mechanism and devices for pollution control.

UNIT V - ENVIRONMENTAL PROTECTION AND CARBON CREDITS  9
Global environmental concern - United Nations framework convention on climate change (UNFCC), protocol, conference of parties (COP), clean development mechanism (CDM), prototype carbon funds, carbon credits and trading, benefits to developing countries, building a CDM project.

Total Hours = 45 Hours

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<tr>
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<td>2</td>
<td>Cunningham, W.P</td>
<td>Environmental Science</td>
<td>Tata McGrawHill</td>
<td>2010</td>
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<td>Letcher T.M</td>
<td>Future Energy</td>
<td>Elsevier</td>
<td>2008</td>
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<tr>
<td>3</td>
<td>Chauhan D.S, Srivastava S.K</td>
<td>Non-Conventional Energy Resources</td>
<td>New Age</td>
<td>2009</td>
</tr>
<tr>
<td>4</td>
<td>Kruger, P</td>
<td>Alternative energy resources</td>
<td>Wiley</td>
<td>2008</td>
</tr>
</tbody>
</table>
OBJECTIVES:
- To learn and study the radiation principles with respective solar energy estimation.
- To learn about PV technology principles and techniques of various solar cells/materials for energy conversion.
- To learn economical and environmental merits of solar energy for variety applications.

INTENDED OUTCOMES:
- Able to suggest and design a solar thermal based applications for a community.
- To become expert in the design of solar photo voltaic based power systems for both domestic and industrial applications.
- Have the potential to apply the concept of utilization of solar energy for the said application in a economical way.

UNIT I  SOLAR RADIATION AND COLLECTORS  9

UNIT II  SOLAR THERMAL TECHNOLOGIES  9

UNIT III  SOLAR PV FUNDAMENTALS  9

UNIT IV  SPV SYSTEM DESIGN AND APPLICATIONS  9
Solar cell array system analysis and performance prediction- Shadow analysis: reliability - solar cell array design concepts - PV system design - design process and optimization - detailed array design - storage autonomy - voltage regulation - maximum tracking - centralized and decentralized SPV systems - stand alone - hybrid and grid connected system - System installation - operation and maintenances - field experience - PV market analysis and economics of SPV systems.

UNIT V  SOLAR PASSIVE ARCHITECTURE  9

Total Hours = 45 Hours
TEXT BOOKS:

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<tr>
<td>2</td>
<td>Chetan Singh Solanki</td>
<td>Solar Photovoltaic’s – Fundamentals, Technologies and Applications</td>
<td>PHI Learning Private limited</td>
<td>2011</td>
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<tr>
<td>3</td>
<td>Roger Messenger and Jerry Vnetre</td>
<td>Photovoltaic Systems Engineering</td>
<td>CRC Press</td>
<td>2010</td>
</tr>
</tbody>
</table>
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 and monitoring

INTENDED OUTCOMES:
- To gain knowledge in conversion techniques of wind energy
- To learn the components and their construction of wind turbine
- To understand the modern wind turbine control and monitoring

UNIT I  WIND ENERGY FUNDAMENTALS & WIND MEASUREMENTS

UNIT II  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 III  GEAR COUPLED GENERATOR WIND TURBINE COMPONENTS AND THEIR CONSTRUCTION

UNIT IV  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 V  MODERN WIND TURBINE CONTROL & MONITORING SYSTEM

Total Hours = 45 Hours
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<tr>
<td>1</td>
<td>Kaldellis J.K</td>
<td>Stand – alone and Hybrid Wind Energy Systems</td>
<td>CRC Press</td>
<td>2010</td>
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<tr>
<td>2</td>
<td>John D Sorensen and Jens N Sorensen</td>
<td>Wind Energy Systems</td>
<td>Woodhead Publishing Ltd</td>
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<tr>
<td>2</td>
<td>Anna Mani</td>
<td>Wind Energy Data for India</td>
<td>Allied</td>
<td>1983</td>
</tr>
</tbody>
</table>
15MERE106 MEASUREMENT AND CONTROL SYSTEMS FOR RES 3 0 0 3

OBJECTIVES:

- To understand the principle and use of sensors for measurement of different thermal and electrical parameters
- To understand the concept of control systems, modes, design and their applications.

INTENDED OUTCOMES:

- To familiar with various measurement techniques useful for the evaluation of energy conservation schemes.
- To become knowledgeable on the design of measurement and control systems for thermal/electrical energy systems.

UNIT-1 INTRODUCTION

Need for measurement, measuring system and characteristics, control of processes and operations, functional elements of an instrument, active and passive transducers, analogue and digital modes of operation, null and deflection methods, input-output configuration, methods of correction, calibration and standards.

UNIT-2 ERROR ANALYSIS

General concept of errors, random and uncertainty, sources of error, definition of error, error estimate and criteria, systematic error and averaging, measurement bias, propagation of uncertainties, final uncertainty of single sample measurement, error control.

UNIT-3 ENERGY AUDIT INSTRUMENTS

Basic methods and characteristics of torque, shaft power, pressure, flow, temperature, lumens, heat flux and radiation measurements, flue gas analysers, electrical variable measurements, standards and calibration.

UNIT-4 PNEUMATIC AND ADVANCED CONTROL SYSTEMS

Pneumatic control systems and controllers, discrete time models, process control algorithms, control of systems with process delay, minimum variance control, parameter identification, filtering.

UNIT-5 DATA ACQUISITION

Cable transmission, fibre optic transmission, pneumatic transmission, analogue signal processing, compact data loggers, instrument interfacing systems, computerized data acquisition and analysis.

Total Hours = 45 Hours

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<td>1</td>
<td>Singh S K</td>
<td>Process Control</td>
<td>PHI Pvt. Ltd</td>
<td>2009</td>
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<td>Ernest O Doebelin</td>
<td>Measurement Systems - Application and Design</td>
<td>McGraw Hill</td>
<td>2004</td>
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<tr>
<td>2</td>
<td>Holman J P</td>
<td>Experimental Methods for Engineers</td>
<td>Mc Graw hill</td>
<td>2004</td>
</tr>
</tbody>
</table>
15MERE201 ELECTRICAL ENERGY CONSERVATION AND MANAGEMENT 3 0 0 3

OBJECTIVES:

- To study the basics of electrical energy usage and means of electrical energy conservation in all utilities including machineries/illumination.
- To study the concepts of power factor, load management etc.

INTENDED OUTCOMES:

- To understand the concept of load management and power factor
- To understand the various measures for energy conservation in electrical devices both static and rotating machineries.

UNIT-1 ELECTRICAL ENERGY AUDIT

Electrical energy use and electrical energy audit, tariff and billing system, energy and demand charges, electrical demand and load factor improvement, power factor correction, power demand control, demand shifting, maximum demand controllers, transmission and distribution losses.

UNIT-2 ELECTRICAL MACHINES

Motors performance characteristics, duties and ratings of motors, motor selection, factors affecting motor performance, efficiency at part load, idle running, VSD drives and applications, load reduction, effect of rewinding on motors performance, energy efficient motors, generators, energy efficient transformers.

UNIT-3 ELECTRICAL ENERGY CONSERVATION IN DRIVEN EQUIPMENTS

Input electrical energy requirements in pumps, fans, and compressors, load factor estimation in the equipments, Energy conservation in pumps, fan and compressors, electrical energy conservation in refrigeration and A/C system, operation and maintenance practices for electrical energy conservation, soft starter with energy saver, case examples.

UNIT-4 DEMAND SIDE MANAGEMENT

Basic concepts, load research importance of demand side management, types of DSM, efficiency gains, estimation of energy efficiency potential, barriers for energy efficiency and DSM, measurement and verification protocols.

INDUSTRIAL LIGHTING: Choice of lighting, energy saving, control of lighting, lighting standards, lighting audit, use of different lighting technologies, electronic ballast.

UNIT-5 ENERGY EFFICIENCY OF INDUSTRIAL DG SETS

Energy efficiency and performance improvement of industrial DG sets, Advantages, disadvantages and application of DG plants, maintenance practices, load matching, PF improvement and parallel operation, waste heat recovery in industrial DG sets.

Total Hours = 45 Hours
### TEXT BOOKS:

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<tr>
<td>1</td>
<td>Openshaw Taylor E</td>
<td>Utilisation of Electric Energy</td>
<td>Orient Longman Ltd</td>
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<td>1</td>
<td></td>
<td>Handbook on Energy efficiency</td>
<td>TERI, New Delhi</td>
<td>2001</td>
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<td>2</td>
<td>Awasthi S K</td>
<td>Energy Conservation</td>
<td>ISTE Publication</td>
<td>1999</td>
</tr>
</tbody>
</table>
OBJECTIVES:

- To study the various issues in grid connection of renewable energy sources.
- To analyse and comprehend the various operating modes of RES

INTENDED OUTCOMES:

- To provide knowledge about the stand alone and grid connected renewable energy systems.
- To equip with required skills to derive the criteria for the design of power system for renewable energy applications.

UNIT I INTRODUCTION TO RENEWABLE ENERGY GRID INTEGRATION


UNIT II INTRODUCTION TO INDUCTION MACHINES

Electrical characteristics, slip, speed torque characteristics etc. Self excited induction generator, Constant speed Induction generators, Variable speed Induction generators, Doubly fed Induction generators.

UNIT III INTRODUCTION TO POWER ELECTRONIC DEVICES

AC/DC converters, PWM, THD. Permanent magnet synchronous generator, solar PV systems, fuel cell, aquaelectrolizer

UNIT IV ISSUES IN RESD GRID CONNECTION

Issues in integration of synchronous generator based, induction generator based and converter based sources together. Network voltage management (discusses the issue of voltage levels).

UNIT V POWER QUALITY AND FREQUENCY MANAGEMENT


Total Hours = 60 Hours

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<tr>
<td>1</td>
<td>Brendan Fox</td>
<td>Wind Power Integration connection and system operational aspect</td>
<td>IET Power and Energy Series</td>
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<td>Wind Energy Generation Modeling and Control</td>
<td>Wiley and Sons</td>
<td>2009</td>
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<td>AJ Wood and BF Wollenberg</td>
<td>Power Generation, Operation and Control</td>
<td>John Wiley &amp; Sons</td>
<td>1996</td>
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</tbody>
</table>
OBJECTIVES:

- To detail on the types of biomass, its surplus availability and characteristics.
- To disseminate the technologies available for utilizing bio-energy and its manifold benefits compared to conventional fossil fuels

INTENDED OUTCOMES:

- To provide knowledge about the various biomass energy conversion technologies and relevance towards solving the present energy crisis.
- To analyze the technologies available for conversion of biomass to energy in terms of its technical competence and economic implications

UNIT I INTRODUCTION


UNIT II BIOMETHANATION


UNIT III COMBUSTION

Perfect, complete and incomplete combustion - stoichiometric air requirement for biofuels - equivalence ratio – fixed Bed and fluid Bed combustion – fuel and ash handling systems – steam cost comparison with conventional fuels

UNIT IV GASIFICATION, PYROLYSIS AND CARBONISATION


UNIT V LIQUIFIED BIOFUELS

History of usage of Straight Vegetable Oil (SVO) as fuel - Biodiesel production from oil seeds, waste oils and algae - Process and chemistry - Biodiesel health effects / emissions / performance. Production of alcoholic fuels (methanol and ethanol) from biomass – engine modifications

Total Hours = 45 Hours
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<td>1</td>
<td>Mahaeswari, R.C</td>
<td>Bio Energy for Rural Energisation</td>
<td>Concepts Publication</td>
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<td>2</td>
<td>Eriksson S. and M. Prior</td>
<td>The briquetting of Agricultural wastes for fuel</td>
<td>FAO Energy and Environment paper</td>
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<td>2</td>
<td>Iyer PVR</td>
<td>Thermochemical Characterization of Biomass</td>
<td>M N E S</td>
<td>1997</td>
</tr>
</tbody>
</table>
Intended Outcome:
- To understand the procedure to be adopted for performance analysis and optimization of energy utilities.
- To understand the methodology for the quantification of performance governing parameters

1. Performance testing of solar hot water collector.
2. I-V and P-V characteristics of Single PV module.
3. Simulation of Photo voltaic system.
5. Determination of calorific value of solid/liquid fuels/gaseous fuels.
8. Energy balance test on SI and CI engines.
10. Study on tower design.
OBJECTIVES:

- To understand the principle of energy efficient machines
- To design and development of energy efficient machines

INTENDED OUTCOMES:

- To analyze the performance of energy efficient machines
- To become expert in the design of energy efficient devices based systems for both domestic and industrial applications

UNIT-1 INTRODUCTION

UNIT-2 MOTOR SELECTION CONSIDERATIONS

UNIT-3 ENERGY EFFICIENT DESIGN OF 3- PHASE IM
Design classification - Matching the motor to the load Prime characteristics — Load shedding saves Energy - design procedure - Replacement Vs Repair - Pay Back Period (PBP) - Thermal modeling and cooling.

UNIT-4 ENERGY EFFICIENT DESIGN OF 1- PHASE IM
Design classification - Matching the motor to the load Prime characteristics - use of advanced materials - Electrical design consideration – selection of optimum capacitor value based on test results – Thermal protectors - General design procedure.

UNIT-5 ENERGY EFFICIENT OPERATION

Total Hours = 45 Hours

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<tr>
<td>2</td>
<td>John C Andreas</td>
<td>Energy Efficient Electric Motor Selection and Application</td>
<td>Marcel Dekker Publisher</td>
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<td>The Induction Machine Handbook</td>
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<td>Holman J P</td>
<td>Experimental Methods for Engineers</td>
<td>Mc Graw hill</td>
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<td></td>
<td>Handbook on Energy Efficiency,</td>
<td>TERI</td>
<td>2001</td>
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</table>
LIST OF ELECTIVES-I & II

15MERE2E01 ADVANCED ENERGY STORAGE TECHNOLOGIES 3 0 0 3

OBJECTIVES:

- To understand and analyse the various types of energy storage.
- To study the various application of energy storage systems and perform the selection based on techno-economic view point

INTENDED OUTCOMES:

- To design and analysis techniques used for various storage systems.
- To understand the techniques used for storing thermal energy in heating and cooling applications

UNIT I  INTRODUCTION

Necessity of energy storage – types of energy storage – comparison of energy storage technologies – Applications

UNIT II  THERMAL STORAGE SYSTEM

Thermal storage – Types – Modelling of thermal storage units – Simple water and rock bed storage 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 III  ELECTRICAL ENERGY STORAGE

Fundamental concept of batteries – measuring of battery performance, charging and discharging of a battery, storage density, energy density, and 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 IV  FUEL CELL


UNIT V  ALTERNATE ENERGY STORAGE TECHNOLOGIES

Flywheel , Super capacitors, Principles & Methods – Applications, Compressed air Energy storage, Concept of Hybrid Storage – Applications

Total Hours = 45 Hours

REFERENCES

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<tr>
<td>1</td>
<td>Ru-shiliu, Leizhang, Xueliang sun</td>
<td>Electrochemical technologies for energy storage and conversion</td>
<td>Wiley publications</td>
<td>2012</td>
</tr>
<tr>
<td>2</td>
<td>James Larminie and Andrew Dicks</td>
<td>Fuel cell systems Explained</td>
<td>Wiley publications</td>
<td>2003</td>
</tr>
</tbody>
</table>
OBJECTIVES:

- To provide information on various methods of waste management
- To make student realize on the importance of healthy environment

INTENDED OUTCOMES:

- To familiarize students with recent energy generation techniques
- To gain the knowledge on the recent technologies of waste disposal

UNIT I  CHARACTERISTICS AND PERSPECTIVES  9

UNIT II  UNIT OPERATIONS & TRANSFORMATION TECHNOLOGIES  9
Separation & Processing : Size Reduction – Separation through Density Variation, Magnetic / Electric Field : Densification - Physical, Chemical and Biological Properties and Transformation Technologies – Selection of Proper Mix of Technologies

UNIT III  WASTE DISPOSAL  9

UNIT IV  TRANSFORMATION TECHNOLOGIES AND VALUE ADDITION  9

UNIT V  HAZARDOUS WASTE MANAGEMENT & WASTE RECYCLING  9

Total Hours = 45 Hours

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<tbody>
<tr>
<td>1</td>
<td>LaGrega, M</td>
<td>Hazardous Waste Management</td>
<td>McGraw-Hill</td>
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</table>
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<td>1</td>
<td>Tchobanoglous, Theisen and Vigil</td>
<td>Integrated Solid Waste Management</td>
<td>Mc Graw-Hill</td>
<td>1993</td>
</tr>
<tr>
<td>2</td>
<td>Stanley E. Manahan</td>
<td>Hazardous Waste Chemistry, Toxicology and Treatment</td>
<td>Lewis Publishers</td>
<td>1990</td>
</tr>
<tr>
<td>3</td>
<td>Howard S. Peavy</td>
<td>Environmental Engineering</td>
<td>McGraw Hill</td>
<td>1985</td>
</tr>
</tbody>
</table>
OBJECTIVES:

- To understand the energy transfer process in mechanical and electrical system.
- To study the software tools to solve problems

INTENDED OUTCOMES:

- To understand and apply the various numerical methods to solve equations
- Able to design and analyze by using various algorithms.

UNIT-1 INTRODUCTION TO THERMAL DESIGN

Basics of fluid flow and heat transfer required for design of energy systems, mathematical analysis, regression analysis and curve fitting.

UNIT-2 MODELING OF ENERGY CONVERSION EQUIPMENTS

Development of design philosophy and governing relations for thermal configurations to heat exchangers, motors, fans, pumps, compressors, turbines, piping, ducts, etc. and efficiency analysis.

UNIT-3 SYSTEM SIMULATION

Steady state simulation of energy systems, using successive substitution, computational simulation, Newton Raphson method, examples.

UNIT-4 OPTIMIZATION

Optimization of energy systems using search methods, geometric programming, dynamic programming, linear programming, search methods, genetic algorithms and neural network.

UNIT-5 DYNAMIC SYSTEM SIMULATION

Differential equation models, interactive modeling, system identification, parameter estimation, thermodynamic properties, graph theory and object oriented simulation.

Total Hours = 45 Hours

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<tbody>
<tr>
<td>1</td>
<td>Robert F Boehm</td>
<td>Developments in the Design of Thermal Systems</td>
<td>Cambridge University Press</td>
<td>2005</td>
</tr>
<tr>
<td>3</td>
<td>Smith T F</td>
<td>Thermal Fluid System Design Notes</td>
<td>The University of Iowa</td>
<td>2001</td>
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</tr>
<tr>
<td>3</td>
<td>Bejan A Tsatsaronis G and Moran M</td>
<td>Thermal Design and Optimization</td>
<td>John Wiley and Sons</td>
<td>1998</td>
</tr>
</tbody>
</table>
OBJECTIVES:

- To learn the principle of heat transfer process in various systems.
- To learn the concept of crystallization and techno economics aspects of industrial systems.

INTENDED OUTCOMES:

- To design the load estimation and energy conservation methods for various processes.
- To calculate the availability of the systems and cycle in industrial processes.

UNIT-1 INTRODUCTION

Material and energy balances of different manufacturing industries, major process equipments and their characteristics, performance evaluation, specific energy consumption analysis.

UNIT-2 HEAT TRANSFER SYSTEMS AND EQUIPMENTS

Heat transfer principles and coefficient evaluation, evaluation of jacketed pan, heating coils immersed in liquids, refrigeration cycles and refrigerant, mechanical equipments, freezing and cold storage systems.

UNIT-3 ABSORPTION& ADSORPTION

Theory of absorption, extraction and washing equipments, performance evaluat. Desiccant and adsorption systems in vehicles, energy recovery systems, chemical dehumidification, cold storage.

UNIT-4 CRYSTALLIZATION

Theory and types of crystallization, membrane separation, chiller equipments, performance evaluation.

MECHANICAL SEPARATION

Cyclones, centrifuges, filters, size reduction equipments, mixers, chemical reactors and bio-reactors, performance evaluation.

UNIT-5 COOLING TOWERS

Cooling tower system, types, performance parameters – range, approach, cycles of concentration, effectiveness, cooling tower losses, factors affecting performance, flow control strategies, energy saving opportunities, performance improvement.

Total Hours = 45 Hours

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<tbody>
<tr>
<td>1</td>
<td>Royce N Brown</td>
<td>Compressors: Selection and Sizing</td>
<td>Gulf Professional Publishing</td>
<td>2005</td>
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OBJECTIVES:

- To understand the principle of refrigeration and air-conditioning systems.
- To learn the energy efficient design of refrigeration and air-conditioning systems.

INTENDED OUTCOMES:

- To gain the knowledge of energy conservation opportunities in refrigeration and air-conditioning systems.
- To design and analyze the most economics aspect in refrigeration and air-conditioning systems.

UNIT I: REFRIGERATION CYCLES
Refrigerators and heat pumps, reversed Carnot cycle, ideal and actual vapour compression refrigeration cycles, selection of refrigerants, heat pump systems, gas refrigeration cycles, absorption refrigeration systems, thermo-electric refrigeration systems. compressors, evaporators, condensers, throttle valves, properties of refrigerants, refrigerants and the ozone layer.

UNIT II: AIR-CONDITIONING
Introduction p-h, T-S, p-v and psychometric charts: comfort air-conditioning and industrial air-conditioning, factors affecting human comfort, air quality and standards, air conditioning for tropical climates, load types, determination of cooling load, air-conditioning systems and equipment selection, design of ducting and piping systems installation, commissioning and maintenance of refrigeration equipments, thermal storage systems.

UNIT III: ENERGY CONSERVATION IN REFRIGERATION AND AIR-CONDITIONING SYSTEMS
Factors affecting refrigeration and air-conditioning system performance and savings opportunities, flow control, strategies and energy conservation opportunities in fans, blowers, compressors and pumps.

UNIT IV: HEAT RECOVERY
Exhaust air heat recovery, refrigeration cycle heat recovery, evaporative cooling, solar cooling and heating and ice storage, hybrid types and applications, IAQ requirement.

UNIT V: SYSTEM DESIGN USING TOOLS
Use of softwares for energy efficient design of refrigeration and air-conditioning systems.

Total Hours = 45 Hours

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<tr>
<td>1</td>
<td>Jones W P</td>
<td>Air Conditioning Engineering</td>
<td>Butterworth-Heinemann, Oxford and Boston</td>
<td>2001</td>
</tr>
</tbody>
</table>

REFERENCES:
OBJECTIVES:

- To learn the green buildings concepts applicable to modern buildings
- Acquaint students with the principle theories materials, construction techniques and to create energy efficient buildings

INTENDED OUTCOMES:

- Able to do energy audit in any type for buildings and suggest the conservation measures
- To gain the knowledge of renewable energy systems for buildings.

UNIT I: INTRODUCTION
The sun-earth relationship and the energy balance on the earth's surface, climate, wind, solar radiation, and solar temperature, sun shading and solar radiation on surfaces, energy impact on the shape and orientation of buildings, thermal properties of building materials.

UNIT II: ESTIMATION OF BUILDING LOADS
Steady state method, network method, numerical method, correlations, computer packages for carrying out thermal design of buildings and predicting performance.

UNIT III: ENERGY EFFICIENT TECHNOLOGIES FOR BUILDINGS
Passive cooling and day lighting, active solar and photovoltaic, building energy analysis methods, building energy simulation, building energy efficiency standards, lighting system design, lighting economics and aesthetics, impacts of lighting efficiency.

UNIT IV: INDOOR ENVIRONMENTAL QUALITY REQUIREMENT AND MANAGEMENT
Psychrometry, comfort conditions, thermal comfort, ventilation and air quality, air conditioning requirement, visual perception, illumination requirement, auditory requirement, energy management options, energy audit and energy targeting, technological options for energy management.

UNIT V: GREEN BUILDINGS
Ecological sustainable design, life cycle analysis, barriers to green buildings, green building rating tools, material selection, embodied energy, operating energy, façade systems, ventilation systems, transportation, water treatment systems, water efficiency, building economics, leed and IGBC codes.

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<tr>
<td>1</td>
<td>Edward G Pita</td>
<td>An Energy Approach-Air-conditioning Principles and Systems</td>
<td>Pearson Education</td>
<td>2003</td>
</tr>
<tr>
<td>2</td>
<td>Colin Porteous</td>
<td>The New Eco-Architecture</td>
<td>Spon Press</td>
<td>2002</td>
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<tbody>
<tr>
<td>2</td>
<td>Ganesan T P</td>
<td>Energy Conservation in Buildings</td>
<td>ISTE Professional Center</td>
<td>1999</td>
</tr>
</tbody>
</table>
OBJECTIVES:
- To provide knowledge about the stand alone and grid connected renewable energy systems
- To learn different power converters namely AC to DC, DC to DC and AC to AC converters for RES

INTENDED OUTCOMES:
- To equip with required skills to derive the criteria for the design of power converters for renewable energy applications.
- To analyse and comprehend the various operating modes of wind and solar systems.
- To develop maximum power point tracking algorithms.

UNIT I: INTRODUCTION 9
Trends in energy consumption - World energy scenario – Energy sources and their availability - Conventional and renewable sources - Need to develop new energy technologies

UNIT II: PHOTOVOLTAIC ENERGY CONVERSION AND APPLICATIONS 9
Solar radiation and measurement - Solar cells and their characteristics - Influence of insolation and temperature - PV arrays-Introduction to flexible solar cells - Electrical storage with batteries - Solar availability in India - Switching devices for solar energy conversion - Maximum power point tracking. Stand alone inverters - Charge controllers - Water pumping, Street lighting - Analysis of PV Systems

UNIT III: POWER CONDITIONING SCHEMES 9

UNIT IV: WIND ENERGY SYSTEMS 9

UNIT V: GRID CONNECTED WECS 9
Grid connectors concepts - Wind farm and its accessories - Grid related problems - Generator control - Performance improvements - Different schemes - AC voltage controllers - Harmonics and PF improvement- Wind / Solar PV integrated systems.

Total Hours = 45 Hours
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<tr>
<td>2</td>
<td>Rai G D</td>
<td>Non-conventional Energy Sources</td>
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<td>Roger A Messenger</td>
<td>Photovoltaic System Engineering</td>
<td>CRC Press</td>
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<td></td>
<td>Jerry Ventre</td>
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<td>2</td>
<td>Thomas Markvart</td>
<td>Practical Handbook of</td>
<td>Elsevier Publications</td>
<td>2003</td>
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<td></td>
<td>and Luis Castaser</td>
<td>Photovoltaics</td>
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<td>Nasar</td>
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OBJECTIVES:

- To develop the ability to understand / analyse the various types of energy storage
- To study the various applications of energy storage systems

INTENDED OUTCOMES:

- Able to analyse various types of energy storage devices and perform the selection based on techno-economic view point.
- To gain the knowledge of various applications of energy storage systems.

UNIT I: FLUIDIZED BED COMBUSTION
Clean coal technologies — Fluidized bed combustion — particles and fluidization. Fluidized bed heat transfer — Types of fluidized bed combustion — Design of simple fluidized beds.

UNIT II: CIRCULATING FLUIDIZED BED
Introduction to circulating fluidized bed - Hydrodynamics - Solids motion and mixing in circulating fluidized beds - Combustion performance – Design considerations for CFB boilers -Applications of CFB technology to gas-solid reactions - Design and scale-up of CFB catalytic reactors.

UNIT III: COMBINED CYCLE
Combined cycle power generation - topping and Bottoming cycles - Variations - Matching of power cycles - Base and peak load considerations vis-à-vis efficiency.

UNIT IV: INTEGRATED GASIFICATION COMBINED CYCLE
Integrated gasification combined cycle - Gasifier - Operation and Configuration details Fuel flexibility and other issues.

UNIT V: FUEL CEL
Fuel cell based power generation - types of fuel cells, Solid oxide and proton exchange membrane type fuel cells - Power generation and automotive applications, fuel cell based combined cycles - fuel cell stacks - relative performance.

Total Hours = 45 Hours

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<td>1</td>
<td>Ibrahim Dincer and Mark A.Rosen</td>
<td>Thermal energy storage systems and applications</td>
<td>John wiley &amp; Sons</td>
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<td>Fuel cell systems explained</td>
<td>Willey publications</td>
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<td>Electrochemical technologies for energy storage and conversion</td>
<td>Willey publications</td>
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OBJECTIVES:
The student will learn
- The basic concepts of co-generation, integrated energy systems and their applications.
- Thermodynamic Analysis of Heat Transfer Equipment
- Economics of Integrated energy systems

INTENDED OUTCOMES:
- To understand the cogeneration technologies based on steam turbine, gas turbine and IC engine.
- To gain the issues and applications of cogeneration technologies

UNIT I: CO-GENERATION
Concept of cogeneration - Combined cycles for power generation and process heat - Topping and Bottoming cycles - Thermodynamic analysis of Integrated energy systems includes Fuel Cell based combined cycle plants.

UNIT II: INTEGRATED ENERGY SYSTEMS
Comparative thermodynamic performance of integrated energy systems - Performance evaluation - Numerical examples - calculations of typical heat to power ratios and performance parameters - Effect of irreversibility.

UNIT III: THERMODYNAMIC ANALYSIS OF HEAT TRANSFER EQUIPMENT
Thermodynamic analysis of waste heat recovery, Second law perspective, Waste heat recovery equipment and design, Organic fluid system design, Heat pipe heat exchangers and heat pumps.

UNIT IV: APPLICATIONS OF INTEGRATED ENERGY SYSTEMS
Applications of integrated energy systems - Diesel generators case studies in sugar mills, rice mills, textile factories and other process and engineering industries.

UNIT V: ECONOMICS OF INTEGRATED ENERGY SYSTEMS
Economics of integrated energy systems, Operating and maintenance costs, Investment costs of waste heat recovery and cogeneration systems, environmental and air quality considerations.

Total Hours = 45 Hours

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<tr>
<td>1</td>
<td>Boyce M.P</td>
<td>Cogeneration and combined cycle plants</td>
<td>ASME press</td>
<td>2010</td>
</tr>
<tr>
<td>2</td>
<td>Charles H.Butler</td>
<td>Cogeneration</td>
<td>McGraw Hill</td>
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<td>Khartchenko N.V</td>
<td>Green power: Eco-friendly energy engineering</td>
<td>Tech book</td>
<td>2004</td>
</tr>
</tbody>
</table>
OBJECTIVES:
The student will learn
- The basics of energy economics
- The economic analysis of energy system
- The concepts and methods of energy economics to renewable energy system

INTENDED OUTCOMES:
- To understand the calculation of energy and energy policies
- Able to do energy audit and suggest the conservation measures
- To gain the knowledge of cogeneration and recyclers of waste energy.

UNIT I: BASIC CONCEPTS OF ENERGY ECONOMICS  9
Law of demand, Elasticities of demand, Theory of firm: Production function, output maximization, cost minimization and profit maximization principles. Theory of market, National income and other macroeconomic parameters. Calculation of unit cost of power generation from different sources with examples Ground rules for investment in Energy sector, Payback period, NPV, IRR and Benefit-cost analysis with example

UNIT II: OVERVIEW OF ENERGY POLICIES  9
National energy policy in the last plan periods, Energy use and Energy supply, Overview of renewable energy policy and the Five Year Plan programmes, Basic concept of Input-Output analysis, Concept of energy multiplier and implication of energy multiplier for analysis of regional and national energy policy

UNIT III: MODELS AND ANALYSIS OF ENERGY DEMAND  9
Analysis of Environmental Pollution through decomposition of different sectors using I-O model, Interdependence of energy, economy and environment, Modeling concepts and application of SIMA model and I-O model for energy policy analysis, Simulation and forecasting of future energy demand consistent with macroeconomic parameters in India. Basic concept of Econometrics (OLS) and statistical analysis (Multiple Regression), Econometrics techniques used for energy analysis and forecasting with case studies from India

UNIT IV: ENERGY AUDIT  9
Definition, need, and types of energy audit; Energy management (audit) approach: Understanding energy costs, bench marking, energy performance, matching energy use to requirement, maximizing system efficiencies, optimizing the input energy requirements; Fuel & energy substitution; Energy audit instruments; Energy Conservation Act; Duties and responsibilities of energy managers and auditors.

UNIT V: THERMAL ENERGY MANAGEMENT  9
Energy conservation in boilers, steam turbines and industrial heating systems;; Cogeneration and waste heat recovery; Thermal insulation; Heat exchangers and heat pumps; Building Energy Management.

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<td>1</td>
<td>YP Abbi and Shashank Jain</td>
<td>Handbook on Energy Audit and Environment Management</td>
<td>TERI Publications</td>
<td>2006</td>
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</table>
OBJECTIVES:
- To impart knowledge on conventional power plants.
- To understand the economics of power generation and utilization of electrical energy for various applications.

INTENDED OUTCOMES:
- To understand the electrical power generation systems and transmission system.
- To understand the distribution system and utilization of electrical energy.
- To gain the knowledge of electrical drives in industry and traction.

UNIT I: ELECTRIC POWER GENERATING SYSTEMS 9
Principles of electrical generators and alternators — Economics of generation, tariffs — economic operation of generating units — dynamic programming.

UNIT II: TRANSMISSION SYSTEM 9
OH, UG transmission, HVDC transmission, voltage levels, relative merits and demerits - single line diagram, per unit representation - computational line inductance, capacitance, ABCD parameters - long line theory, surge impedance loading, line compensation.

UNIT III: DISTRIBUTION SYSTEMS & SUB-STATIONS DISTRIBUTION SYSTEMS 9
AC & DC distribution systems, radial systems, ring main system - Kelvins law, distributors fed at one end, both ends, uniformly loaded - comparison of distribution systems. Sub-stations Indoor, Outdoor & pole mounted sub-stations - Bus bar systems, single bus bar, sectionalized bus bar, duplicate bus bar etc - layout of sub-stations.

UNIT IV: UTILIZATION OF ELECTRICAL ENERGY 9
Types of consumers, domestic, industrial, traction, agricultural etc and models - Electric heating & welding - Resistance heating, Induction heating, Arc furnace heating, dielectric heating etc. - illuminating systems - Polar curves, Laws of illumination, flood and street lighting schemes - Electrolytic Process - Laws of electrolysis, Calculation of energy, consumption in electrolytic process.

UNIT V: ELECTRIC DRIVES IN INDUSTRY AND TRACTION 9

Total Hours = 45 Hours
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<tr>
<td>1</td>
<td>CL wadhwa</td>
<td>Generation Distribution and Utilization of Electrical Energy</td>
<td>New Age India Pvt Ltd</td>
<td>2011</td>
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<tr>
<td>2</td>
<td>Uppal SL</td>
<td>A Course in Electric Power</td>
<td>Khanna Publications</td>
<td>2003</td>
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<td>3</td>
<td>OlleElgerd</td>
<td>Electric energy systems</td>
<td>TMH Publications</td>
<td>1983</td>
</tr>
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</table>
LIST OF ELECTIVE-III AND ELECTIVE-IV

15MERE3E12 ELECTRICAL DRIVES AND CONTROL 3 0 0 3

OBJECTIVES:
The student will learn
- Conventional motor drives and physical phenomena in electrical machines
- Principles of solid power controllers and super conductivity
- Working of solid state motor controllers

INTENDED OUTCOMES:
- To understand the characteristics of DC and AC motors
- To gain the knowledge of various losses in electrical machines
- To understand the usage of drives for various applications

UNIT I: REVIEW OF CONVENTIONAL MOTOR DRIVES 9
Characteristics of DC and AC motors for various applications -starting and speed control -methods of breaking

UNIT II: PHYSICAL PHENOMENA IN ELECTRICAL MACHINES 9
Various losses in motors - Saturation and Eddy current effects -mmf harmonics and their influence of leakage - stray losses -vibration and noise.

UNIT III: INTRODUCTION TO SOLID STATE POWER CONTROLLERS 9
Power devices - Triggering Circuits - Rectifiers - Choppers. Invertors - AC Controllers

UNIT IV: SUPERCONDUCTIVITY 9
Super conducting generators - motors and magnets - Super conducting magnetic energy storage (SMES).

UNIT V: SOLID STATE MOTOR CONTROLLERS 9

Total Hours = 45 Hours

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<td>1</td>
<td>Pillai, S.K</td>
<td>A First Course on Electrical Drives</td>
<td>Wiley Eastern Ltd</td>
<td>2002</td>
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<tr>
<td>2</td>
<td>Dewan, S.B.,</td>
<td>Power Stream and Control Drives</td>
<td>John Wiley &amp; Sons</td>
<td>2001</td>
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<td></td>
<td>Slevnon,G.R., Strangher</td>
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<td>1</td>
<td>Eedam Subramanyan</td>
<td>Thyristor Control of Electrical Drives</td>
<td>Tata McGraw-Hill</td>
<td>2008</td>
</tr>
<tr>
<td>2</td>
<td>Rakesh Dal Begamudre</td>
<td>Electro Mechanical Energy Conversion with Dynamics of Machines</td>
<td>Wiley Eastern Ltd</td>
<td>2003</td>
</tr>
</tbody>
</table>

WEBSITES:
OBJECTIVES:
The student will learn
- The optimal power flow and hydrothermal Co-ordination
- Unit commitments and constrains
- Maintenance scheduling

INTENDED OUTCOMES:
- To understand and give solution for OPF problems
- To gain the knowledge of hydro thermal co-ordination

UNIT I: INTRODUCTION
Operational problems of power systems-review of economic dispatch and loss formula calculations.

UNIT II: OPTIMAL POWER FLOW
Formulation of OPF Problem — cost minimization — loss minimization — solution using NLP methods successive LP methods.

UNIT III: HYDROTHERMAL CO-ORDINATION
Long Range and Short Range hydro scheduling — Short Term hydrothermal Scheduling — a gradient approach — solution method using iteration and dynamic programming.

UNIT IV: UNIT COMMITMENT
Constraints in Unit commitment-thermal unit constraints — hydro constraints — solution methods — priority list methods — dynamic programming solution.

UNIT V: MAINTENANCE SCHEDULING
Preparation of maintenance schedules for generating units-turbines-boilers-taking into account forced outages and normal outages— optimal maintenance scheduling using mathematical programming.

Total Hours = 45 Hours

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<tbody>
<tr>
<td>1</td>
<td>Allen Wood, J. and Bruce Wollenberg, F</td>
<td>Power Generation, Operation and Control</td>
<td>John Wiley &amp; Sons</td>
<td>2006</td>
</tr>
</tbody>
</table>

WEBSITES:

48
OBJECTIVES:
The student will learn
- The basics of computer applications
- Computer based information system and data base management system
- Software engineering and computer based monitoring

INTENDED OUTCOMES:
- To understand the expert based systems for energy management
- To gain the knowledge of programming language

UNIT I: INTRODUCTION OF COMPUTER APPLICATION
9
Programming languages - Introduction to Visual C++, C-Programming Design - Computer Organization

UNIT II: INTRODUCTION TO COMPUTER BASED INFORMATION SYSTEM
9
Types of CBIS -Relationship among CBIS systems concepts and CBIS-general systems theory - Energy Management concepts and CBIS

UNIT III: DATABASE MANAGEMENT SYSTEM
9
Intelligence based systems - energy data bases -networking - time sharing concepts.

UNIT IV: SOFTWARE ENGINEERING
9
The need for and scope of software engineering - survey of software life cycle models - Transform theory of software performance - network model of structured programs.

UNIT V: COMPUTER BASED MONITORING AND ONLINE CONTROL SYSTEMS
9
Data acquisition system - expert based systems for energy management - Parallel Processing Concepts - Typical applications in energy management area.

Total Hours = 45 Hours

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<td>1</td>
<td>Herbert Schildt</td>
<td>C/C++ PROGRAMMER'S reference</td>
<td>McGraw-Hill</td>
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<tr>
<td>2</td>
<td>David McMahon</td>
<td>Rapid Application Development with Visual C++</td>
<td>McGraw-Hill</td>
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<td>1</td>
<td>Gerrit Blaauw</td>
<td>Frederick Brooks, Computer Architecture: Concepts and Evolution</td>
<td>Addison Wesley</td>
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<td>2</td>
<td>Ian Sommerville</td>
<td>Software Engineering</td>
<td>England Addison Wesley</td>
<td>2011</td>
</tr>
<tr>
<td>3</td>
<td>Peter Jackson</td>
<td>Introduction to Expert Systems</td>
<td>Addison Wesley</td>
<td>2012</td>
</tr>
</tbody>
</table>
OBJECTIVES:
- To study the properties of nanomaterials and nanostructures.
- To study the applications of nanomaterials in solar system and fuel cell

INTENDED OUTCOMES:
- To gain the knowledge of nanostructures and nanomaterials in solar energy storage
- To gain the knowledge of nanomaterials in the fuel cell and hydrogen technology

UNIT I - PROPERTIES OF NANOMATERIALS
Introduction to nanomaterial, nano dimensional materials, classification of nanomaterials, bulk materials and nanomaterials – changes in bulk and nanomaterials of silicon, silver, gold. General methods of preparation of nanomaterials, thermal and thermo-electric properties of nano structures - modeling and metrology. Nanowires, nanostructures, nanocomposites.

UNIT II - NANOMATERIALS FOR SOLAR THERMAL CONVERSION
Conversion of thermal energy - Nanostructures and nanomaterials, materials selection criteria, particle-scale effect. Phase compositions on nanoscale microstructures. Nanoparticles for conduction heat transfer, coatings on fins.

UNIT III - NANO APPLICATIONS IN THERMAL ENERGY STORAGE

UNIT IV - NANOMATERIALS FOR PHOTOVOLTAICS

UNIT V - NANOMATERIALS IN FUEL CELL APPLICATIONS
Use of nanostructures and nanomaterials in fuel cell technology - high and low temperature fuel cells, cathode and anode reactions, fuel cell catalysts, electrolytes, ceramic catalysts. Use of nano technology in hydrogen production and storage.

Total Hours = 45 Hours

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<tr>
<td>2</td>
<td>Maheshwar Sharon, Madhuri Sharon</td>
<td>Nano forms and Applications</td>
<td>McGraw-Hill</td>
<td>2010</td>
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<td>3</td>
<td>Tsakalakos.L</td>
<td>Nanotechnology for Photovoltaic</td>
<td>CRC</td>
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<tr>
<td>4</td>
<td>Allhoff F</td>
<td>What is Nanotechnology</td>
<td>Wiley</td>
<td>2010</td>
</tr>
</tbody>
</table>
OBJECTIVES:
- To familiarize the students with the methods of modeling and analysis of solar thermal and PV systems
- To understand and apply the solar system using various software techniques.

INTENDED OUTCOMES:
Upon successful completion of the course the students are able to understand and apply the
- Mathematical modeling development methods.
- Quantitative techniques.
- Various numerical methods to solve equations.
- Software tools to solve problems.

UNIT I - MATHEMATICAL MODELING 9
Mathematical modeling overview – Types, stages, choosing the modeling equations, levels of analysis, steps in model development, solving and testing of models.

UNIT II - QUANTITATIVE TECHNIQUES 9
Quantitative techniques – Interpolation - Polynomial, Lagrangian curve fitting, regression analysis and solution of transcendental equations.

UNIT III - NUMERICAL METHODS 9

UNIT IV - SOFTWARE TOOLS 9
Overview of effective tools for solar energy systems - RET Screen - Evaluation of the energy production and savings of renewable energy and energy efficient technologies, TRNSYS - Dynamic simulation of solar heating and cooling systems, GREENIUS - Simulation, design and analysis of solar thermal electric and photovoltaic systems, PVSYST - Sizing, simulation and analysis of photovoltaic systems.

UNIT V - ENERGY OPTIMIZATION 9
Case studies of energy system optimization – Application - Analysis and design of solar thermal and photovoltaic systems.

Total Hours = 45 Hours

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<td>Bender E.A</td>
<td>Introduction to Mathematical Modeling</td>
<td>Dover Publication</td>
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<td>2</td>
<td>Meyer W.J</td>
<td>Concepts of Mathematical Modeling</td>
<td>Dover Publication</td>
<td>2004</td>
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<td>3</td>
<td>Dym C.L</td>
<td>Principles of Mathematical Modeling</td>
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OBJECTIVES:

- To study the various research methodologies, analysis and report writing.
- To perform various sampling tests and prepare effective report.

INTENDED OUTCOMES:

Upon successful completion of the course the students are able to

- Understand the research preparation and planning.
- Understand various data collection methods.
- Study various sampling methods

UNIT I - RESEARCH PREPARATION AND PLANNING
Research methodology - Definition, mathematical tools for analysis. Types of research - exploratory research, conclusive research, modeling research and algorithmic research. Research process steps.

UNIT II - DATA COLLECTION METHODS
Data collection method - Primary data - Observation method, personal interview, telephonic interview, mail survey and questionnaire design.Secondary data- Internal sources of data, external sources of data.Scales - Measurement.

UNIT III - SAMPLING METHODS
Sampling methods - Probability sampling methods, simple random sampling with and without replacement, stratified sampling, cluster sampling. Non- probability sampling method - convenience sampling, judgment sampling and quota sampling

UNIT IV - SAMPLING TESTS
Hypotheses testing - Testing of hypotheses, concerning variance - one tailed Chi-square test, nonparametric tests, one sample tests, one sample sign test, Kolmogorov-Smirnov test, run test for randomness, two sample tests, two sample sign test, Mann-Whitney U test, K-sample test - Kruskal Wallis test(H-Test).

UNIT V - ANALYSIS AND REPORTING
Introduction to discriminant analysis, factor analysis, cluster analysis, multidimensional scaling and conjoint analysis. Report writing - types of reports, guidelines to review report, typing instructions and oral presentation.

Total Hours = 45 Hours

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<td>1</td>
<td>Ganesan R</td>
<td>Research Methodology for Engineers</td>
<td>MJP Publishers</td>
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<td>3</td>
<td>Kothari C.K</td>
<td>Research Methodology Methods and Techniques</td>
<td>New Age International</td>
<td>2004</td>
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<tr>
<td>4</td>
<td>Panneerselvam R</td>
<td>Research Methodology</td>
<td>PHI Learning</td>
<td>2012</td>
</tr>
</tbody>
</table>
OBJECTIVES:

- To learn the mass and energy balances for the systems enable to perform enthalpy
- To study the modeling, system simulation and optimization techniques

INTENDED OUTCOMES:

- To understand the modelling and analysis techniques to improve and optimize the performance
- To design and analyse the size performance and cost of energy equipments turns modeling and simulation techniques and to optimize the energy system.

UNIT I INTRODUCTION

Primary energy analysis - energy balance for closed and control volume systems - applications of energy analysis for selected energy system design - modeling overview - levels and steps in model development - Examples of models – curve fitting and regression analysis

UNIT II MODELING AND SYSTEMS SIMULATION

Modeling of energy systems – heat exchanger - solar collectors – distillation -rectification turbo machinery components - refrigeration systems - information flow diagram - solution of set of nonlinear algebraic equations - successive substitution - Newton Raphson method- examples of energy systems simulation

UNIT III OPTIMISATION TECHNIQUES


UNIT IV ENERGY- ECONOMY MODELS


UNIT V APPLICATIONS AND CASE STUDIES

Case studies of optimization in Energy systems problems- Dealing with uncertainty- probabilistic techniques – Trade-offs between capital and energy using Pinch analysis

Total Hours = 45 Hours

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<td>1</td>
<td>Stoecker, W.F</td>
<td>Design of Thermal Systems</td>
<td>McGraw Hill</td>
<td>2011</td>
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<tr>
<td>2</td>
<td>C. Balaji</td>
<td>Essentials of Thermal System Design and Optimization</td>
<td>Aue Books</td>
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<td>1</td>
<td>Yogesh Jaluria</td>
<td>Design and Optimization of Thermal Systems</td>
<td>CRC Press INC</td>
<td>2008</td>
</tr>
</tbody>
</table>
OBJECTIVES:

- To describe fundamental study of nuclear reactions
- To learn nuclear fuels cycles, characteristics. Fundamental principles governing nuclear fission chain reaction and fusion
- To discuss future nuclear reactor systems with respect to generation of energy, fuel breeding, incineration of nuclear material and safety.

INTENDED OUTCOMES:

- To understand the fundamentals of nuclear reactions
- To gain knowledge in nuclear fission chain reaction and fusion
- To give awareness about reprocessing of spent and waste disposal

UNIT I NUCLEAR REACTIONS
Mechanism of nuclear fission - nuclides - radioactivity – decay chains - neutron reactions - the fission process - reactors - types of fast breeding reactor - design and construction of nuclear reactors – heat transfer techniques in nuclear reactors - reactor shielding

UNIT II REACTOR MATERIALS
Nuclear Fuel Cycles - characteristics of nuclear fuels - Uranium - production and purification of Uranium - conversion to UF4 and UF6 - other fuels like Zirconium, Thorium – Beryllium

UNIT III REPROCESSING
Nuclear fuel cycles - spent fuel characteristics - role of solvent extraction in reprocessing – solvent extraction equipment.

UNIT IV SEPARATION OF REACTOR PRODUCTS
Processes to be considered - 'Fuel Element' dissolution - precipitation process – ion exchange - redox- purex - TTA - chelation -U235 - Hexone - TBP and thorax Processes - oxidative slaging and electro - refining - Isotopes - principles of Isotope separation.

UNIT V WASTE DISPOSAL AND RADIATION PROTECTION
Types of nuclear wastes - safety control and pollution control and abatement - international convention on safety aspects - radiation hazards prevention

Total Hours = 45 Hours

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<td>Cacuci, Dan Gabriel</td>
<td>Nuclear Engineering Fundamentals</td>
<td>Springer</td>
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<td>2</td>
<td>Kenneth D</td>
<td>Nuclear Engineering</td>
<td>CRC Press</td>
<td>2009</td>
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<tr>
<td>2</td>
<td>Tatjana Tevremovic</td>
<td>Nuclear Principles in Engineering</td>
<td>Springer</td>
<td>2008</td>
</tr>
</tbody>
</table>
OBJECTIVES:

- To study the energy scenario and the environmental issues related to the power plants
- To learn the various utilities in the power plants and the avenues for optimizing them.

INTENDED OUTCOMES:

- To understand the advances in operation and applications of different types of power plants
- To understand the possible mitigation of anthropogenic emissions by optimizing the power plant cycles/utilities.

UNIT I INTRODUCTION
Overview of Indian power sector – load curves for various applications – types of power plants – merits and demerits – criteria for comparison and selection - Economics of power plants.

UNIT II STEAM POWER PLANTS

UNIT III DIESEL AND GAS TURBINE POWER PLANTS

UNIT IV ADVANCED POWER CYCLES

UNIT V HYDROELECTRIC & NUCLEAR POWER PLANTS

Total Hours = 45 Hours

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<td>Haywood, R.W</td>
<td>Analysis of Engineering Cycles</td>
<td>Pergamon Press</td>
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<td>2</td>
<td>Arora and Domkundwar</td>
<td>A course in power Plant Engineering</td>
<td>Dhanpat Rai and CO</td>
<td>2004</td>
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<tr>
<td>3</td>
<td>Gill, A.B</td>
<td>Power Plant Performance</td>
<td>Butterworths</td>
<td>2013</td>
</tr>
</tbody>
</table>
OBJECTIVES:
- To understand the working of various fuel cells, its types and to elaborate on its thermodynamics and kinetics
- To detail on the hydrogen production methodologies, possible applications and various storage options.

INTENDED OUTCOMES:
- To gain the knowledge of fuel cell technology, hydrogen production, storage and utilization.
- To analyze the cost effectiveness and eco-friendliness of fuel cells and hydrogen

UNIT-1 INTRODUCTION TO FUEL CELLS
Fuel cell concept, key components, physical and chemical phenomena in fuel cells, advantages and disadvantages of fuel cells, different types of fuel cells and their characteristics. fuel cells for stationary applications, fuel cell vehicles.

UNIT-2 THERMODYNAMIC ANALYSIS
Systematic enthalpy change of a reacting system, systematic gibbs free energy, change of a reacting system, ideal efficiency of the energy conversion, energy balance in fuel cells.

UNIT-3 ELECTROCHEMISTRY
Nernst equation, relation of the fuel consumption versus current output, stoichiometric coefficients and utilization percentages of fuels and oxygen, mass flow rate calculation for fuel and oxygen in single cell and fuel cell stack, total voltage and current for fuel cells in parallel and serial connection, over-potential and polarizations, DMFC operation scheme, general issues-water flooding and water management, polarization in PEMFC, optimization design of PEMFC – case studies.

UNIT-4 HYDROGEN ECONOMY
Introduction to hydrogen economy, production, storage and transportation systems, hydrogen from fossil fuels, electrolysis of water, thermochemical cycles, baseline and alternative thermochemical cycles.

UNIT-5 HYDROGEN UTILISATION
Hydrogen for automotive applications, transmission and Infrastructure requirements, safety and environmental impacts, economics of transition to hydrogen systems, case studies.

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<td>2</td>
<td>Rebecca L. and Busby</td>
<td>Hydrogen and Fuel Cells: A Comprehensive guide</td>
<td>Penn well corporation</td>
<td>2005</td>
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<td>Hydrogen and Fuel cells: Emerging technologies and applications</td>
<td>Elsevier</td>
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<td>2</td>
<td>Peter Hoffman</td>
<td>Tomorrow’s Energy – Hydrogen Fuel Cells and the Prospects for Cleaner Planet</td>
<td>MIT</td>
<td>2002</td>
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<tr>
<td>3</td>
<td>Jeremy Rifkin</td>
<td>The hydrogen economy</td>
<td>Penguin group</td>
<td>2002</td>
</tr>
</tbody>
</table>
OBJECTIVES:
• To study the energy scenario and the environmental issues aspects
• To learn the important of Kyoto protocol, CDM mechanism and Emission trading

INTENDED OUTCOMES:
• To understand all aspects of the Kyoto Protocol’s project-based mechanisms
• To understand the CDM and JI project cycles and corresponding rules and procedures.

UNIT - 1 CLIMATE SCIENCE
World Energy Scenario - Observed and Modeled changes in Climate - Role of Aerosols - Climate Change Scenarios - Global Warming – Factors contributing – Comparison of Global warming potential of GHG - Impacts

UNIT - 2 KYOTO PROTOCOL: FORMATION
Historical perspectives from the Industrial Revolution to the United Nations Framework Convention on Climate Change and the Kyoto Protocol, the Intergovernmental Panel on Climate Change (IPCC)

UNIT - 3 KYOTO PROTOCOL
Article 1 through 28 - accounted GHGs in Kyoto protocol – Source categorization of GHG emissions – Reduction commitment of Annexe B countries – C D M, Joint Implementation & Emissions Trading

UNIT - 4 CLEAN DEVELOPMENT MECHANISM & BASELINE STUDY SCENARIO
Green and red industries, CDM and its economic viability for Renewable Energy Projects – Advantages for Developing Countries – Emission & Efficiency Scenario of different energy sources for power generation.
Baseline Study – Methodology – Boundary Conditions– Base Line fixing – Typical Case Studies.

UNIT - 5 RECENT ADVANCEMENTS
Certification program – Emission trade – Policy and implications

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<td>John Houghton</td>
<td>Global Warming: The Complete Briefing</td>
<td>Cambridge University Press</td>
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<td>2</td>
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<td>Caring for Climate : a guide to the climate change convention and the Kyoto protocol</td>
<td>UNFCC</td>
<td>2003</td>
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