REGULATIONS - 2013

DEPARTMENT OF
MECHANICAL ENGINEERING

CURRICULUM AND SYLLABI OF
M.E. – ENERGY ENGINEERING
Programme Educational Objectives (PEOs)

➢ Produce researchers in the field of Renewable and Non-renewable Energy Technology.
➢ Prepare students to pursue research for emerging as a good academician in a leading Institution as well as acquire full-fledged knowledge in the technological advancements of a specific energy field to serve in an industry.
➢ Equip the students to understand and evaluate alternative modes of energy source and planning of energy source-demand chain.

Programme Outcomes (POs)

The students will attain the following outcomes:

a. an ability to apply knowledge of mathematics, science, and engineering to the field of study to pursue research and excel as professionals in the various fields of Energy Engineering
b. an ability to apply energy, momentum, continuity, state and constitutive equations to thermal, fluids and Energy systems in a logical and discerning manner.
c. an ability to create, select and apply appropriate techniques, resources, and modern engineering tools, including prediction and modeling, to complex energy engineering activities, with an understanding of the limitations.
d. an ability to design solutions for complex energy systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and ethical considerations.
e. an ability to understand energy and environmental problems and conduct investigations of various renewable energy technologies including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions.
f. an ability to understand the potential in Solar Energy, the energy of future and to develop the technologies that make it economical for the production of energy.
g. an ability to communicate effectively on energy engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
h. an ability to function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary settings.
REGULATIONS - 2013

M.E. ENERGY ENGINEERING
CURRICULUM I TO IV SEMESTERS (FULL TIME)

SEMESTER I

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TOTAL 18 1 3 21

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TOTAL 18 0 6 21

*Mini Project*: Studies to demonstrate simple basic concepts and aspects of various Energy Technologies have to be carried out by the students which will be evaluated by the Internal Examiner.
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#Phase I: Review of Literature, Problem Identification, Methodology, Work Plan, theoretical modeling (if any), Presentation and Viva.

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**Phase II**: Experimental and/or theoretical analysis, Results and discussions, Presentation and Viva

TOTAL CREDITS TO BE EARNED FOR THE AWARD OF THE DEGREE - 69
## ELECTIVES FOR M.E ENERGY ENGINEERING (FULL TIME)

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M.E. (ENERGY ENGINEERING)
CURRICULUM I TO VI SEMESTERS (PART TIME)

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*Mini Project: Studies to demonstrate simple basic concepts and aspects of various Energy Technologies have to be carried out by the students which will be evaluated by the Internal Examiner.

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#Phase I: Review of Literature, Problem Identification, Methodology, Work Plan, theoretical modeling (if any), Presentation and Viva.

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**Phase II: Experimental and/or theoretical analysis, Results and discussions, Presentation and Viva

TOTAL CREDITS TO BE EARNED FOR THE AWARD OF THE DEGREE - 69
### ELECTIVES FOR M.E ENERGY ENGINEERING (PART TIME)

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#### Semester - V

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EEC11 - ADVANCED THERMAL ENGINEERING

COURSE OUTCOMES
1. Able to understand the basics of thermodynamics and various improvements possible in vapor power cycles and refrigeration cycles.
2. Ability to use the heat transfer concepts for various applications like finned systems & turbulence flows.
3. Capability to perform the thermal analysis and sizing of heat exchangers and to learn the heat transfer coefficient for compact heat exchanges.

UNIT I THERMODYNAMICS

UNIT II VAPOR POWER CYCLES

UNIT III REFRIGERATION

UNIT IV HEAT TRANSFER
Introduction to heat transfer processes, Heat transfer from finned surfaces; fin efficiency and effectiveness, two dimensional steady state heat conduction using analytical and numerical methods - Radiation from a black body & grey body - Quantitative analysis of heat transfer co-efficient for all the modes of heat transfer.

UNIT V HEAT EXCHANGERS

Tutorial: 15 Periods
Total: 60 Periods

REFERENCES:
EEC12 - INSTRUMENTATION AND CONTROL IN ENERGY SYSTEMS

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COURSE OUTCOMES
1. To be familiar with the basic instruments for measurement of specific thermo physical properties
2. Able to understand the advanced measurement techniques
3. Able to develop fundamental knowledge of system control and process parameters

UNIT I MEASUREMENT CHARACTERISTICS

UNIT II MEASUREMENT OF PHYSICAL QUANTITIES
Measurement of thermo – physical properties, instruments for measuring temperature - pressure and flow

UNIT III ADVANCE MEASUREMENT TECHNIQUES

UNIT IV CONTROL SYSTEMS

UNIT V DATA ACQUISITION AND PROCESSING
Multi Channel Data acquisition system – Architecture of data acquisition and computer control system - Compact Data loggers – Sensor based, Computerized data systems - Micro – computer interfacing - Intelligent instruments in use.

TOTAL PERIODS: 45

REFERENCES:
ECC13 - ELECTRICAL TECHNOLOGY FOR ENERGY ENGINEERS

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**COURSE OUTCOMES**

1. Able to understand the basic working principles of Electrical & Electronic devices
2. Able to understand various types of Transformers & Motors with energy efficiency perspective
3. Capable of analyzing and understanding storage concepts of electricity
4. To be familiar with the concepts of Electricity Transmission & Distribution
5. Able to understand the concepts of Wheeling and Power Evacuation of Wind & Solar Power

**UNIT I INTRODUCTION**


**UNIT II ELECTRICAL ENERGY STORAGE**


**UNIT III ELECTRICITY TRANSMISSION & DISTRIBUTION**


**UNIT IV ELECTRICAL SYSTEM FOR WIND ENERGY SYSTEMS**


**UNIT V ELECTRICAL SYSTEM FOR SOLAR ENERGY SYSTEMS**


**TOTAL PERIODS: 45**

**REFERENCES:**

EEC14 - ENERGY PLANNING, CONSERVATION AND MANAGEMENT

COURSE OUTCOMES

1. The present energy scenario and the need for energy conservation and various energy conservation measures would be learnt.
2. Talented to understand the concepts of Energy Planning and forecasting techniques for performing energy analysis.
3. Be aware of the methods of pollution controls produced during energy generation.
4. To be familiar with various energy policies (National and International) & standards.

UNIT I INTRODUCTION


UNIT II ENERGY FORECASTING TECHNIQUES

Energy demand – supply balancing, Energy models, Software for energy planning, 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 III POLLUTION FROM ENERGY GENERATION


UNIT IV ENERGY POLICIES

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- Carbon Trading- Renewable Energy Certification - CDM

UNIT V ENERGY CONSERVATION AND AUDITING

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.

TOTAL PERIODS: 45

REFERENCES:

EEE15 - RENEWABLE ENERGY SOURCES, CONVERSION AND TECHNOLOGY

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COURSE OUTCOMES
1. Able to understand the basic principles of concept of various forms of renewable energy
2. Be familiar with the concept of Solar radiation and Energy conversion
3. Able to understand the concepts of extraction of Wind Energy
4. Able to understand the concepts of various Bio-Energy Conversion techniques
5. Be familiar with the concepts of Hydrogen Energy and other forms of Renewable Energy

UNIT I SOLAR ENERGY
Solar radiation its measurements and prediction - solar thermal flat plate collectors concentrating collectors – applications - heating, cooling, desalination, power generation, drying, cooking etc - principle of photovoltaic conversion of solar energy, types of solar cells and fabrication. Photovoltaic applications: battery charger, domestic lighting, street lighting, and water pumping, power generation schemes.

UNIT II WIND ENERGY

UNIT III BIO-ENERGY
Biomass resources and their classification - chemical constituents and physicochemical characteristics of biomass - Biomass conversion processes - Thermo chemical conversion: direct combustion, gasification, pyrolysis and liquefaction - biochemical conversion: anaerobic digestion, alcohol production from biomass - chemical conversion process: hydrolysis and hydrogenation. Biogas - generation - types of biogas Plants- applications

UNIT IV HYDROGEN AND FUEL CELLS
Thermodynamics and electrochemical principles - basic design, types, and applications - production methods - Biophotolysis: Hydrogen generation from algae biological pathways - Storage gaseous, cryogenic and metal hydride and transportation. Fuel cell – principle of working- various types - construction and applications.

UNIT V OTHER TYPES OF ENERGY
Ocean energy resources - principles of ocean thermal energy conversion systems - ocean thermal power plants - principles of ocean wave energy conversion and tidal energy conversion – hydropower – site selection, construction, environmental issues - geothermal energy - types of geothermal energy sites, site selection, and geothermal power plants.

TOTAL PERIODS: 45

REFERENCES:
EEC16 - WASTE MANAGEMENT AND ENERGY RECOVERY

COURSE OUTCOMES
1. Provision of information on various methods of waste management
2. Familiarization of the students with recent energy generation techniques
3. Knowledge on recent technologies of waste disposal
4. Importance of healthy environment will be realized.

UNIT I SOLID WASTE – CHARACTERISTICS AND PERSPECTIVES 06
Definition - types – sources – generation and estimation. Properties: physical, chemical and biological – regulation

UNIT II COLLECTION, TRANSPORTATION AND PROCESSING TECHNIQUES 08
Onsite handling, storage and processing – types of waste collection mechanisms - transfer Stations: types and location – manual component separation – volume reduction: mechanical, thermal – separation: mechanical, magnetic electro mechanical

UNIT III LIQUID WASTE MANAGEMENT 16

UNIT IV HAZARDOUS WASTE MANAGEMENT 08

UNIT V ULTIMATE DISPOSAL 07

TOTAL: 45 PERIODS

REFERENCES
EEC17 - ENERGY LAB – I

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RENEWABLE ENERGY
1. Performance testing of Solar Water Collector
2. Characteristics of Solar photovoltaic devices
   - Investigation of PV Characteristics – Amorphous Silicon.
   - Investigation of PV Characteristics – Amorphous Silicon – Shadow effect
   - Comparative Performance Analysis of Mono & Poly Crystalline Silicon PV cell
3. Testing of Gasifier
4. Properties of Fuels
   - Determination of Flash and Fire Point using Pensky Marten Apparatus
   - Determination of Flash and Fire Point using Abel Apparatus
   - Determination of Density and Dynamic Viscosity of oil using Redwood Viscometer
5. Solar Radiation measurement
6. Performance testing of Solar Air Heater
7. Performance testing of Solar Still
8. Performance Study on Concentric Collectors
9. Study of biogas plant

ENERGY CONSERVATION
1. Performance Test of Parallel flow and Counter flow Heat Exchanger
2. Energy consumption measurement of lighting systems
3. Performance Test on Vapour Compression Refrigeration Systems
4. Performance Test on Air conditioning Systems

ADVANCED ENERGY SYSTEMS
1. Thermal Storage Systems

TOTAL: 45 PERIODS
EEC21 - SOLAR ENERGY AND UTILIZATION

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COURSE OUTCOMES
1. Knowledge on radiation principles with respective solar energy estimation
2. Be familiar with various collecting techniques of solar energy and storage
3. PV technology principles and techniques of various solar cells / materials for energy conversion will be learnt
4. Economical and environmental merits of solar energy for variety of applications will be understood

UNIT - I SOLAR RADIATION 09

UNIT II SOLAR COLLECTORS 09

UNIT III PHOTOVOLTAIC SYSTEMS 09
Conversion of Solar energy into Electricity - Photovoltaic Effect, Photovoltaic material - Solar Cell – Module – Silicon solar cell, Efficiency limits, Variation of efficiency with band-gap and temperature, Efficiency measurements, High efficiency cells, Recent developments in Solar Cells- PV systems - applications

UNIT IV ENERGY STORAGE 09
Sensible Heat Storage – Liquid media storage – Solid media storage – Latent heat storage - Phase change materials – Chemical storage

UNIT V INDUSTRIAL APPLICATIONS OF SOLAR HEAT 09

REFERENCES
EEC22 - WIND ENERGY TECHNOLOGY

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COURSE OUTCOMES
1. The fundamentals of wind energy and its conversion system will be comprehended
2. To be familiar with the wind measurement techniques
3. Be aware of the concepts of aerodynamics, wind farms and cycles

UNIT I WIND CHARACTERISTICS AND RESOURCES 09

UNIT II AERODYNAMICS OF WIND TURBINES 09

UNIT III MODERN WIND TURBINE CONTROL & MONITORING SYSTEM 09

UNIT IV CONCEPT OF WIND FARMS 09
Wind Farms - Site Preparation-Installation and Operation Issues - Wind Farms in Electrical Grids-Typical Grid-connected Turbine Operation. Environmental concerns: Pollution free power; Noise; birds; Aesthetics, Radio waves, interference, Rainfall,

UNIT V ECONOMICS ANALYSIS 09

TOTAL: 45 PERIODS

REFERENCES:
EEC23 - BIO ENERGY ENGINEERING

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COURSE OUTCOMES
1. Knowledge on the types of biomass, its surplus availability and characteristics.
2. Capability 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 BIO - METHANATION

UNIT III COMBUSTION

UNIT IV GASIFICATION

UNIT V PYROLYSIS AND CARBONIZATION

TOTAL: 45 PERIODS

REFERENCES
# EEC24 - ENERGY LAB – II

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## I Cycle (using ANSYS)

- Steady State Conductive Heat Transfer Analysis in a cubical block
- Analysis of Thermal Mixed Boundary for an infinitely long block
- Analysis of Transient Thermal Heat Conduction for an infinitely long block
- Study of temperature distribution along a Straight rectangular stainless steel cooling fin
- Determination of heat conducted by a Cooling Spine
- Laminar Flow Analysis in a 2D Duct
- Analysis of flow in a System of Pipes to compute the velocity distribution

## II Cycle (using TRNSYS)

- Performance analysis of Solar PV panel
- Performance analysis of Flat Plate Collecting System
- Performance analysis of Evacuated Tube Collecting System
- Performance analysis of Concentrated Solar Thermal Collecting System
- Simulation of Solar Water Heating System
- Cooling tower Analysis

**TOTAL: 45 PERIODS**
ELECTIVE SUBJECTS

EEE2A - HYDRO POWER TECHNOLOGY

Course Outcomes
1. Able to understand the basic concepts of aerodynamics, horizontal and vertical axis wind turbines, small hydro system components and design
2. Ability to develop prototype systems
3. Ability to select and analyze the particular turbine for specific need

UNIT I HYDROLOGY
Overview of Hydropower systems-Preliminary Investigation- Rainfall and Run of measurements-Hydrographs- flow duration graph and mass storage graphs- Determination of site selection- types hydro electric power plants- General arrangements and Layouts- Preparation of Reports and Estimates-Review of World Resources-Basic Factors in Economic Analysis of Hydropower projects-Project Feasibility-Load Prediction and Planned Development.

UNIT II DEVELOPMENT OF PROTOTYPE SYSTEMS

UNIT III SELECTION AND ANALYSIS OF TURBINES
Measurement of pressure head, Velocity- Various parameters for finding out the potential of Hydro Energy- Selection of turbines based on Specific quantities- Performance characteristics – Testing of hydraulic turbines - Governing of Impulse and reaction turbines.

UNIT IV HYDRO POWER STATION OPERATION, MAINTENANCE AND TROUBLE SHOOTING

UNIT V SMALL, MINI AND MICRO HYDRO POWER PLANTS TURBINES
Introduction – Analysis of Small, mini and micro hydro turbines – Economical and Electrical Aspects of Small, mini and micro hydro turbines- potential developments – Design and reliability of Small, mini and micro hydro turbines – Case Study. A compulsory Seminar/ Assignment on Design/Case Study/Analysis/Application in any one the Small, Mini and Micro Hydro Power Plants and Components (viz..Turbines, Controls, and Storage etc.)

Total: 45 PERIODS

REFERENCES:
EEE2B - NUCLEAR ENGINEERING

**COURSE OUTCOMES**
1. Knowledge on fundamentals of nuclear reactions
2. Be able to learn nuclear fuels cycles, characteristics, fundamental principles governing nuclear fission chain reaction and fusion
3. Awareness on future nuclear reactor systems with respect to generation of energy, fuel breeding, incineration of nuclear material and safety.

**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: 45 PERIODS**

**REFERENCES:**
EEE2C - INDUSTRIAL ENERGY MANAGEMENT

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COURSE OUTCOMES

1. Be aware of present energy scenario and the need for energy conservation and various energy conservation measures
2. Concepts of basic measurement, instruments for measuring various parameters in energy systems, energy auditing, digital data processing, computer data processing, etc. will be familiarized

UNIT I INTRODUCTION

09

UNIT II INSTRUMENTS FOR ENERGY AUDITING

09

UNIT III STEAM SYSTEMS

09
Properties of steam - Steam distribution - Assessment of steam distribution losses Steam leakages, Steam trapping - Condensate recovery and flash steam utilisation system, Identifying opportunities for energy savings -Thermal Insulation. Boiler –efficiency testing, excess air control

UNIT IV WASTE HEAT RECOVERY

09

UNIT V ELECTRICAL SYSTEMS

09
Demand control, power factor correction, load scheduling/shifting, Motor drives- motor efficiency testing, energy efficient motors, motor speed control. Lighting- lighting levels, efficient options, fixtures, day lighting, timers, Energy efficient windows. Energy conservation in Pumps, Fans (flow control), Compressed Air Systems, Refrigeration & air conditioning systems.

TOTAL: 45 PERIODS

REFERENCES:

EEE2D - COGENERATION AND WASTE HEAT RECOVERY SYSTEMS

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COURSE OUTCOMES
1. Importance of cogeneration in improving the overall efficiency, thus reducing fuel consumption, improving economy and limiting global warming will be brought out
2. Capability to analyze the basic energy generation cycles
3. Detailed knowledge of concepts of cogeneration, its types and probable areas of applications
4. To study the significance of waste heat recovery systems and carry out its economic analysis

UNIT I INTRODUCTION 09

UNIT II COGENERATION TECHNOLOGIES 09

UNIT III ISSUES AND APPLICATIONS OF COGENERATION TECHNOLOGIES 09

UNIT IV WASTE HEAT RECOVERY SYSTEMS 09

UNIT V ECONOMIC ANALYSIS 09

TOTAL: 45 PERIODS

REFERENCES
EEE2E - ALTERNATIVE FUELS

COURSE OUTCOMES
1. Able to get an insight into the availability of petroleum based fuels, their progress and its influence on environment.
2. Able to get an exposure to the need, production and technology of utilizing different alternative liquid and gaseous fuels for transportation which include alcohol, biodiesel, CNG, LPG, DME, DEE and hydrogen

UNIT I OVERVIEW

UNIT II VEGETABLE OILS AND OTHER SIMILAR FUELS DERIVED

UNIT III NATURARAL GAS AND LPG

UNIT IV HYDROGEN AS ALTERNATIVE FUEL

UNIT V BIOGAS FOR IC ENGINES

TOTAL: 45 PERIODS

REFERENCES
7. IEEE Journals for “Power, Energy, & Industry Applications”
EEE2F - SOLAR ARCHITECTURE

COURSE OUTCOMES
1. Ability to elaborate the current trends in solar architecture and following key concepts: Solar Passive Architecture and heat transfer in buildings
2. Able to understand the Natural Heating/Cooling concepts for Building, Earth to Air Heat Exchanger, Thermal Comfort Requirements

UNIT I INTRODUCTION

UNIT II PASSIVE HEATING & COOLING CONCEPTS
Passive heating concepts: Direct heat gain, indirect heat gain, isolated gain and sunspaces, Solar Green Houses, Solar Wall, Solar Trombe wall Evaporative cooling, radiative cooling, Application of wind, water and earth for cooling, Shading, paints and cavity walls for cooling, Roof radiation traps, Earth air-tunnel systems for cooling

UNIT III THERMAL ANALYSIS AND DESIGN FOR HUMAN COMFORT
Thermal comfort, Criteria and various parameters, Psychometric chart, Thermal indices, Climate and comfort zones, Concept of sol-air temperature and its significance, Calculation of instantaneous heat gain through building envelope, Calculation of solar radiation on buildings, Building orientation, Introduction to design of shading devices, Overhangs, Factors that affect energy use in buildings, Ventilation and its significance, Air-conditioning systems

UNIT IV HEAT TRANSMISSION IN BUILDINGS
Surface co-efficient: air cavity, internal and external surfaces, overall thermal transmittance, Wall and windows, Heat transfer due to ventilation/infiltration, internal heat transfer, solar temperature, Decrement factor, Phase lag, Day lighting, Estimation of Building loads: Steady state method, network method, numerical method, correlations

UNIT V PASSIVE SOLAR DESIGNS OF BUILDING
Thumb rules for design of buildings and building codes, Typical design of selected buildings in various climatic zones, Simulation Software’s for carrying out thermal design of buildings and predicting performance

REFERENCES
5. DS Lal “Climatology”, Sharda Pustak Bhawan, Allahabad, 2003
8. IEEE Journals for “Power, Energy, & Industry Applications”

TOTAL: 45 PERIODS
EEE2G - FLUIDIZED BED SYSTEMS

COURSE OUTCOMES
1. Understand the concepts of fluidization and heat transfer in fluidized beds.
2. Able to understand the design principles and apply the same for industrial applications.

UNIT I FLUIDIZED BED BEHAVIOUR 12

UNIT II HEAT TRANSFER 06

UNIT III COMBUSTION AND GASIFICATION 06

UNIT IV DESIGN CONSIDERATIONS 09

UNIT V INDUSTRIAL APPLICATIONS 12
Physical operations like transportation, mixing of fine powders, heat exchange, coating, drying and sizing. Cracking and reforming of hydrocarbons, carbonization, combustion and gasification. Sulphur retention and oxides of nitrogen emission control.

TOTAL: 45 PERIODS

REFERENCES:
EEE2H - ADVANCED POWER PLANT ENGINEERING

COURSE OUTCOMES
1. Able to understand the energy scenario and the environmental issues related to the power plants.
2. Familiarized with various improvements possible in steam cycles, gas power cycles.
3. Be aware of the advances in nuclear and MHD power plants.
4. Able to study the economic feasibility of various power plants.

UNIT I ANALYSIS OF STEAM POWER PLANTS (SPP): 09
Components of steam power plants, typical layout, Rankine Cycle – performance - energy analysis of Rankine cycle - cycle improvements – Ideal reheat Rankine cycle - The Ideal Regenerative Rankine Cycle - Open Feedwater Heaters - Closed Feedwater Heaters

UNIT II ANALYSIS OF HYDROELECTRIC POWER PLANTS (HEPP): 09
Components of HEPP, typical layout, Classification of Hydraulic Turbines - Pelton, Francis, Kaplan, Propeller, Deriaz and Bulb turbines – specific speed – hydraulic efficiency and comparison - Performance of turbines – Constant head characteristics, Constant speed characteristics and Constant efficiency curves.

UNIT III ANALYSIS OF GAS TURBINE POWER PLANTS: 09

UNIT IV NUCLEAR AND MHD POWER PLANTS: 09
Overview of Nuclear power plants - radioactivity - fission process- reaction rates - elastic scattering and slowing down - criticality calculations – critical heat flux - power reactors - nuclear safety. MHD and MHD - steam power plants

UNIT V ECONOMIC ASPECTS OF POWER PLANT OPERATION: 09
Load curves, load factor, diversity factors and their significance, Economic scheduling of power stations. Interest and depreciation, Costs of electrical energy, Methods of determining depreciation Tariff, characteristics and types of tariff. Economic efficiency - Payback period and Net-present value methods to assess financial efficiency of power plants

TOTAL: 45 PERIODS

REFERENCES:
EEE2J - MATERIALS SCIENCES AND ENGINEERING

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COURSE OUTCOMES
1. Knowledge in advanced materials to make him aware of the vast selection of engineering materials.
2. Able to analyze the crystal structure by knowing the bonding of materials.
3. Student will be well-versed with the magnetic, electrical and thermal properties of materials.

UNIT I ADVANCED MATERIALS
Materials and Engineering, Types of materials - Metallic materials - Dual phase steels, High strength low alloy (HSLA) steel, Transformation induced plasticity (TRIP) Steel—Advanced structural ceramics, WC, TIC, Al₂O₃, SiC, Si₃N₄, and diamond –properties, processing and applications - Future trends in materials usage

UNIT II ATOMIC STRUCTURE AND BONDING
Structure of atoms- Bohr’s atomic model-Sommerfeld’s extension of atomic structure; Electronic structure - Electronic configuration and Quantum numbers; Shapes of s,p,d,f orbitals - Pauli’s exclusion principle - Hund’s Rule of maximum multiplicity- Aufbau principle, Types of atomic and molecular bonding – Octet rule - Primary Bonds - Ionic Bonds, Covalent Bonds, Metallic Bonds - Secondary Bonds - Permanent Dipole Bonds, Fluctuating Dipole Bonds

UNIT III CRYSTAL STRUCTURE AND CRYSTAL GEOMETRY
Space lattice, crystal systems and Bravais lattices, principal metallic crystal structures, Miller indices, crystallographic planes and directions, comparisons of principle metallic crystal structures, volume and density calculations, crystal structure analysis.

UNIT IV PHASE DIAGRAM AND PHASE TRANSFORMATION

UNIT V MAGNETIC PROPERTIES OF THE MATERIALS
Magnetic Properties - Definition of Magnetic Properties, Types of magnetic bodies, Diamagnetism and Pascal’s Constant, Russell-Saunders or LS Coupling, Multiple width Large compared to kT, Multiple width small compared to kT, Stereo chemical applications of Magnetic Properties of the First Transition Series, Determination of magnetic susceptibility by Gouy’s Method, Derivation of Van Vleck formula for Susceptibility.

TOTAL PERIODS: 45

REFERENCES:
1. W.D.Callister, Jr., "Materials Science and engineering", Wiley India (P) LTD., 2007
EEE2K - ADVANCES IN METALLURGICAL ENGINEERING

COURSE OUTCOMES
1. Able to apply their knowledge of the fundamental concepts and principles in materials and engineering in the development and design of new product, to ensure quality assurance in the practice of material engineering.
2. Able to characterize the synthesized materials.
3. Students will gain fundamental understanding of electrical conduction (transport) in solids, major properties of bulk and nanostructured superconductors.
4. Able to create a scientific basis to ensure the safe and responsible development of engineered nanoparticles and nanotechnology-based materials and products.

UNIT I ADVANCED MATERIALS AND TOOLS 09
Smart materials, exhibiting ferroelectric, piezoelectric, optoelectric, semiconducting behaviour, lasers and optical fibres, photoconductivity and superconductivity, nanomaterials, synthesis, properties and applications.

UNIT II PHYSICAL METHODS FOR CHARACTERIZATION 09
X-ray diffraction, Powder diffraction, Single crystal X-ray diffraction, Electro-optical and related techniques like SEM, TEM, EDS, WDS/EPMA etc.; Spectroscopic techniques - Vibrational, UV-visible and Electron resonance spectroscopies. Thermal analysis (Differential thermal analysis, Thermo gravimetric analysis, Differential scanning calorimetry)

UNIT III ELECTRONIC MATERIALS 09
Dielectric properties, Polarization mechanism, Frequency and Temperature effects, Electrical breakdown, Classification of ferroelectric materials, Piezoelectricity, Capacitor dielectric materials, Insulating materials and Pyroelectric materials, ceramic composites as capacitors & sensors.

UNIT IV SUPERCONDUCTIVITY 09
History and background of superconductivity, Superconducting phenomenon, low temperature Superconductors, Bardeen – Cooper and Schrieffer Theory (BCS), Cooper pair, High temperature Superconductivity. Applications of Superconductors.

UNIT V NANOMATERIALS & NANOTECHNOLOGY 09
Top down and bottom up approaches, classification of nanomaterials, carbon nanotubes (CNT), particulate reinforced metal/ceramic/polymer nanocomposites, Characterization of nanomaterials, Applications of nanotechnology in medicine, automobile sector, Bragg reflector, Butterfly-wings, Different applications.

TOTAL PERIODS: 45

REFERENCES:

EEE2L - DESIGN AND OPTIMIZATION OF ENERGY SYSTEMS  

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COURSE OUTCOMES
After the completion of course the student will be able to
1. Perform the Simulation and Modeling of typical energy system
2. Analyse the effect of constraints on the performance of energy systems
3. Design energy systems and perform Energy-Economic Analysis for typical Applications.

UNIT I  INTRODUCTION  09
Engineering Design- Design as Part of Engineering Enterprise- Thermal Systems

UNIT II  BASIC CONSIDERATIONS IN DESIGN  09

UNIT III  MODELING OF THERMAL SYSTEMS  09
Types of Models- Mathematical Modeling- Physical Modeling and Dimensional Analysis- Curve Fitting

UNIT IV  ECONOMIC CONSIDERATIONS  09
Introduction-Worth of Money as a Function of Time-Series of Payments-Economic Factor in Design- Application to Thermal Systems

UNIT V  OPTIMIZATION  09
Basic Concepts- Optimization Methods- Optimization of Thermal Systems- Practical Aspects in Optimal Design

TOTAL: 45 PERIODS

REFERENCES
7. IEEE Journals for Power, Energy, & Industry Applications
EEE2M - COORDINATION CHEMISTRY  

COURSE OUTCOMES
After the completion of course the student will be able to
• elucidate the structure of the coordination compounds.
• apply the theories and identify the nature of hybridization.
• assign term symbols for any transition metal complexes.
• identify the reaction mechanism of metal complexes.
• describe the keyways by which the biological important metal ion catalysis.

UNIT I  NOMENCLATURE OF METAL COMPLEXES  09

UNIT II  THEORIES OF COORDINATION COMPOUNDS  09
Valence bond theory – Electroneutrality principle and back bonding – Crystal field theory (CFT) – Assumptions of CFT theory – Crystal field splitting of d-orbitals in different geometries – Octahedral, square planar and tetrahedral complexes – Molecular orbital theory of π bonding.

UNIT III  SPECTRAL TERMS OF METAL COMPLEXES  09

UNIT IV  REACTIONS OF METAL COMPLEXES  09
Ligand substitution reactions – SN1, SN2 and SN1CB mechanism – Outer sphere mechanism – Inner sphere mechanism – Trans effect – Theories of trans effect – Applications of trans effect.

UNIT V  BIOLOGICAL IMPORTANCE OF METALS  09
Biological importance of transition metals; Biological roles of Mn, Fe, V, Cu, and Zn in proteins and enzymes – Electron transfer reactions in ferredoxins – Catalysis – blue-copper proteins – Metalloenzymes.

TOTAL: 45 PERIODS

REFERENCES
EEE2N - PHYSICAL ORGANIC CHEMISTRY

COURSE OUTCOMES
After the completion of course the student will be able to
1. draw mechanism, knowledge, reactivity and their structure in various molecular rearrangement.
2. recall reagents and predict products for a defined set of organic reactions and to propose mechanism.
3. determine the electronic structure of solids and crystal / (dis) order and defects.
4. outline the mechanistic aspect for the important photochemical reaction.
5. evaluate and choose appropriate reagent for selective functional group transformations and to discuss the mechanism of important organic transformations.

UNIT I     MOLECULAR REARRANGEMENTS

UNIT II     NAME REACTIONS
Mechanism of the following reactions: Aldol condensation – Perkin reaction – Stobbe condensation – McMurry reaction – Fries rearrangement – Sandmeyer reaction – Schmidt rearrangement – Sonogashira coupling reaction – Kolbe reaction.

UNIT III     SOLID STATE
Structure of Solids – Crystalline and amorphous solids – Basic crystal systems – Crystal structures of sodium chloride, zinc blende, wurtzite, rutile – Schottky defects – Frenkel defects – Optical and electrical properties of semiconductors – Photovoltaic effect.

UNIT IV     PHOTOCHEMISTRY
Introduction to photochemical reactions – Cis-trans isomerisation – Paterno-Buchi reaction – Norrish type I & II reaction – Photo reduction of Ketones – Photochemistry of arenes – Barton reaction – Photophysical process.

UNIT V     REAGENTS IN ORGANIC SYNTHESI S

TOTAL: 45 PERIODS

REFERENCES
EEE3A - DESIGN OF HEAT EXCHANGERS

COURSE OUTCOMES
1. Able to understand the basic principles of Heat transfer & Heat Exchangers and applications
2. Able to understand various types of flows and disturbances
3. Able to design Shell & Tube and Double-Pipe Heat Exchanger
4. Able to design Compact and Plate Heat Exchanger
5. Able to design Condenser and performance analysis of Cooling Towers

UNIT I  FUNDAMENTALS OF HEAT EXCHANGER 09

UNIT II  FLOW AND STRESS ANALYSIS 09

UNIT III  DOUBLE PIPE AND SHELL & TUBE HEAT EXCHANGER 09
Introduction to Double pipe heat exchangers – Types – Bare inner tube – finned inner tube - Design – Applications - Shell and tube heat exchangers - Types – Design – sizing of heat exchangers – Pressure drop calculations - Applications

UNIT IV  COMPACT AND PLATE HEAT EXCHANGER 09

UNIT V  CONDENSERS AND COOLING TOWERS 09
Condensers – Types – Shell & tube – Plate condenser - Design - Cooling tower – types – Natural draft – Mechanical draft - performance characteristics – Range and approach of a cooling tower

TOTAL: 45 PERIODS

REFERENCES:
5. IEEE Journals for “Power, Energy, & Industry Applications”
EEE3B - ADVANCED THERMAL STORAGE TECHNOLOGIES  3 0 0 3

COURSE OUTCOMES
1. Familiar with the various types of thermal storage systems and the storage materials
2. Ability to develop the model and analyze the sensible and latent heat storage units
3. Be aware of various applications of thermal storage systems

UNIT I INTRODUCTION 08
Necessity of thermal storage – types - energy storage devices – comparison of energy storage technologies - seasonal thermal energy storage - storage materials.

UNIT II SENSIBLE HEAT STORAGE SYSTEM 09
Basic concepts and modelling of heat storage units - modelling of simple water and rock bed storage system – pressurized water storage system for power plant applications – packed beds.

UNIT III REGENERATORS 10

UNIT IV LATENT HEAT STORAGE SYSTEMS 09
Modeling of phase change problems – temperature based model - enthalpy model - porous medium approach - conduction dominated phase change – convection dominated phase change.

UNIT V APPLICATIONS 09
Specific areas of application of energy storage – food preservation – waste heat recovery – solar energy storage – green house heating – power plant applications – drying and heating for process industries.

TOTAL: 45 PERIODS

REFERENCES
EEE3C - MATERIALS FOR ENERGY APPLICATIONS

COURSE OUTCOMES
1. Able to understand the properties and characteristics of materials used in energy applications
2. Basic design concepts and technologies for manufacturing the solar cells will be acquired
3. Be familiar about various heat storage media viz., rock-bed, earth, Aquifers etc.,

UNIT I MATERIALS
09
Glazing materials, Properties and Characteristics of Materials, Reflection from surfaces, Selective Surfaces: Ideal coating characteristics, Types and applications, Anti-reflective coating, Preparation and characterization, Reflecting Surfaces and transparent materials, Types of Insulation and properties

UNIT II PHYSICS OF SOLAR CELLS
09
Intrinsic, extrinsic and compound semiconductors, Electrical conductivity, Density of electrons and holes, Carrier transport: Drift, diffusion, Absorption of light, Recombination process, Materials for Photovoltaic’s Conversion, Si and Non-Si materials, crystalline, semi-crystalline, Polycrystalline and Amorphous materials, p-n junction: homo and hetero junctions, Metal-semiconductor interface

UNIT III TECHNOLOGY FOR SI EXTRACTION
09
Purification, Method of doping and junction fabrication, Cell fabrication and metallization techniques: Preparation of metallurgical, electronic and solar grade Silicon, Production of single crystal Silicon: Procedure of masking, photolithography and etching, Design of a complete silicon, GaAs, InP solar cell

UNIT IV SENSIBLE HEAT STORAGE MATERIALS
09
Stratified storage systems, Rock-bed storage systems, Thermal storage in buildings, Earth storage, Energy storage in aquifers, Heat storage in SHS systems, Aquifers storage

UNIT V PHASE CHANGE MATERIALS, PIEZOELECTRICITY AND FERROELECTRICITY
09
Selection criteria of Phase change, Materials use in Solar heating or cooling, Research Status Optical properties, Interaction of solids with radiation, Luminescence, Photoconductivity

TOTAL: 45 PERIODS

REFERENCES
7. IEEE Journals for “Power, Energy, & Industry Applications”
EEE3D - NANOTECHNOLOGY AND NANO ELECTRONICS

COURSE OUTCOMES

1. A scientific basis to ensure the safe and responsible development of engineered nanoparticles and nanotechnology-based materials and products.
2. Better knowledge of the risks of nanomaterials for health and the environment will form a solid basis to avoid unnecessary damage and loss of investments; and allow for a sustainable development of the nanotechnology industries and markets.
3. Student will be able to explore, develop, characterize and evaluate unique nanoscale packaging materials for thin film passive components.
4. Familiarize students with semiconductors and devices including the P-N junction, and the transistors.

UNIT I FUNDAMENTALS OF SOLID STATE ENGINEERING: 09
Future of semiconductor device and research. Applications in food, energy, transportation, communication, entertainment, health and medicine etc. Necessity of innovative technology and prospect for future.

UNIT II CRYSTALLINE PROPERTIES OF SOLID: 09
Crystal lattice and seven crystal systems, The unit cell concept, The Weigner-Seitz cell, Bravais lattices, Space and point groups, Miller indices, reciprocal lattice, Brillouin zone.

UNIT III SEMICONDUCTOR HETEROSTRUCTURES AND LOW-DIMENSIONAL QUANTUM STRUCTURES: 09
Energy bands, Application of model solid theory, Anderson model for heterojunctions, Multiple quantum wells (MQWs) and super lattices, Two-dimensional nanostructure: quantum well, One-dimensional nanostructure: quantum wire, Zero-dimensional nanostructure: quantum dot, Optical properties of low-dimensional structures, Examples and applications in real world.

UNIT IV FABRICATION OF NANOSTRUCTURES: 09
Basic compound semiconductors, Bulk single crystal growth techniques, Epitaxial growth techniques, Physical vapour deposition and sputtering, Thermodynamics and kinetics of growths, Nan scale growth modes

UNIT V CHARACTERIZATION TECHNIQUES: 09
Structural, X-ray diffraction, Electron microscopy, Energy dispersive analysis using X-rays, X-ray photoelectron spectroscopy, Secondary ion mass spectroscopy, Rutherford backscattering, Scanning probe microscopy, Optical, Photoluminescence spectroscopy, Absorbance measurement, Raman spectroscopy, Fourier transform spectroscopy.

TOTAL PERIODS: 45

REFERENCES:
COURSE OUTCOMES

2. Familiar with the economical use of the systems

UNIT I INTRODUCTION
Potential and scope of solar cooling, Types of solar cooling systems, solar collectors and storage systems for solar refrigeration and air conditioning.

UNIT II VAPOUR ABSORPTION AND COMPRESSION REFRIGERATION SYSTEMS

UNIT III THERMODYNAMIC MODELLING
Thermal modelling and computer simulation for continuous and intermittent solar refrigeration and air conditioning systems.

UNIT IV SOLAR COOLING SYSTEMS

UNIT V ECONOMICS
Solar thermoelectric refrigeration and air conditioning - solar economics of cooling systems.

TOTAL PERIODS: 45

REFERENCES:

5. IEEE Journals for “Power, Energy, & Industry Applications”
EEE3F - FUEL CELLS AND HYDROGEN ENERGY

COURSE OUTCOMES

1. Knowledge on the hydrogen production methodologies, possible applications and various storage options
2. Ability to converse about the working of a typical fuel cell, its types and to elaborate on its thermodynamics and kinetics
3. Able to analyze the cost effectiveness and eco-friendliness of Fuel Cells

UNIT I FUEL CELL BASICS 09
Fuel cell definition, Difference between batteries and fuel cells, fuel cell history, components of fuel cells, principle of working of fuel cells Fuel cell thermodynamics - second law analysis of fuel cells, efficiency of fuel cells fuel cell electrochemistry - Nernst equation, Electrochemical kinetics, Butler-Volmer equation

UNIT II FUEL CELL TYPES 09
Classification by operating temperature/electrolyte type, Fuel Cell Performance, Activation, Ohmic and Concentration over potential

UNIT III FUEL CELL DESIGN AND COMPONENTS 09
Cell components, stack components, system components Overview of intermediate/high temperature fuel cells - Solid oxide fuel cells (SOFC), Molten carbonate fuel cells (MCFC), Phosphoric acid fuel cells (PAFC) Polymer Electrolyte fuel cells ,Heat and mass transfer in polymer electrolyte fuel cells, water management in PEFCs, Current issues in PEFCs, Direct methanol fuel cells (DMFC) - Electrochemical kinetics methanol oxidation, Current issues in MFCs, Fuel crossover in DMFCs, Water management in DMFCs, high methanol concentration operation, limiting current density

UNIT IV HYDROGEN PRODUCTION METHODS 09
Production of hydrogen from fossil fuels, electrolysis, thermal decomposition, photochemical and photo-catalytic methods.

UNIT V HYDROGEN STORAGE METHODS 09
Metal hydrides, metallic alloy hydrides, carbon nano-tubes, sea as source of deuterium.

TOTAL PERIODS: 45

REFERENCES

4. Xianguo Li, “Principles of Fuel Cells”, Taylor and Francis, 2005
### EEE3H - SOLAR PHOTOVOLTAIC POWER PLANTS: PLANNING, DESIGN AND BALANCE OF SYSTEMS

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<td>1. capable of understanding the physics of photo cells</td>
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<td>2. proficient to differentiate various technologies along with their pros &amp; cons</td>
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<td>3. competent to design &amp; analyze on-grid PV applications</td>
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<td>4. skilled to design &amp; analyze off-grid PV applications</td>
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<td>5. able to realize cost benefit analysis of PV installations</td>
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<th>UNIT I SOLAR CELL FUNDAMENTALS</th>
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<th>UNIT V COMMERCIALS FOR SOLAR PV INSTALLATIONS</th>
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**TOTAL PERIODS: 45**

**REFERENCES**

5. [www.pveducation.org](http://www.pveducation.org)
EEE3K - SPECTROSCOPIC METHODS IN CHEMISTRY

COURSE OUTCOMES
After the completion of course the student will be able to
1. elucidate the electronic transition and the effect of conjugation present in the metal complex.
2. identify the functional group and vibration of any metal complex.
3. predict the splitting pattern and interpret integration of NMR spectra.
4. predict the fragmentation pattern to find molecular mass and to identify the structure of a compound.
5. interpret experiment spectra and analyzing the results to identify the geometry of the compound.

UNIT I ULTRAVIOLET SPECTROSCOPY
Electronic energy levels – Types of electronic excitations in UV-Vis spectroscopy – Change in position and intensity of absorption – Chromophores and auxochromes – Factors affecting the position of UV bands – Application of UV-Vis spectroscopy to transition metal complexes.

UNIT II INFRARED SPECTROSCOPY
Absorption of IR radiation and molecular vibrations – Spectral feature of major functional groups and interpretation of aromatic compounds – Characteristic IR absorption frequencies of important functional groups – Distinction between intermolecular and intramolecular hydrogen bonding – Applications of IR Spectroscopy.

UNIT III NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY
Principles of $^1$H, $^{13}$C NMR – Shielding mechanism – Chemical shift – Spin-Spin coupling – Coupling constants – Splitting of signals – Applications of NMR to organic compounds.

UNIT IV MASS SPECTROMETRY

UNIT V ELECTRON SPIN RESONANCE (ESR) SPECTROSCOPY

TOTAL: 45 PERIODS

REFERENCES
EEE3L - ANALYTICAL CHEMISTRY

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COURSE OUTCOMES
After the completion of course the student will be able to
- select a proper chromatographic technique to isolate the compound.
- apply the knowledge in solving problems / tasks in the field of electro analytical chemistry.
- interpret the data and qualitative estimation by wet chemical analysis.
- evaluate and access chemical reaction and kinetic properties between 0-1600°C for compound.
- expand the knowledge of radiochemical analytical technique.

UNIT I   CHROMATOGRAPHIC METHODS

UNIT II   ELECTRO ANALYTICAL TECHNIQUES
Conductometry and its applications – Potentiometry – pH metry and ion selective electrodes – Electrogravimetry – Cyclic Voltammetry and its applications – Amperometric titrations and applications.

UNIT III  WET CHEMICAL METHODS OF ANALYSIS

UNIT IV   THERMAL METHODS
Principle, theory, instrumentation and applications of thermogravimetry (TGA) – Differential thermal analysis (DTA) – Differential scanning calorimetry (DSC).

UNIT V   RADIOCHEMICAL METHODS

TOTAL: 45 PERIODS

REFERENCES