NATIONAL ENGINEERING COLLEGE

(An Autonomous Institution Affiliated to Anna University Chennai)

K.R.NAGAR, KOVILPATTI – 628 503

REGULATIONS - 2011

Estd :1984

DEPARTMENT OF

MECHANICAL ENGINEERING

(CENTRE FOR ENERGY STUDIES)

CURRICULUM AND SYLLABI OF

M.E. – ENERGY ENGINEERING

NATIONAL ENGINEERING COLLEGE

(An Autonomous Institution Affiliated to Anna University Chennai)

M.E. – ENERGY ENGINEERING

CURRICULUM I TO IV SEMESTERS (FULL TIME)

SEMESTER I

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
1	MEN101	Thermodynamics and Thermal Systems	3	1	0	4
2	MEN102	Fuels and Combustion Technology	3	1	0	4
3	MEN103	Energy Conversion Systems	3	0	0	3
4	MEN104	Non-Conventional Sources of Energy	3	0	0	3
5	MEN105	Environmental Impact of Energy Systems	3	0	0	3
6	E1	Elective I	3	0	0	3
PRACTICAL						
7.	MEN131	Energy Laboratory – I	0	0	3	1
		TOTAL	**18**	**2**	**3**	**21**

SEMESTER II						
SL. No	**COURSE CODE**	**COURSE TITLE**	**L**	**T**	**P**	**C**
1	MEN201	Design and Optimization of Energy Systems	3	1	0	4
2	MEN202	Energy Audit and Management	3	0	0	3
3	MEN203	Analysis of Power Plants	3	0	0	3
4	E2	Elective II	3	0	0	3
5	E3	Elective III	3	0	0	3
6	E4	Elective IV	3	0	0	3
PRACTICAL						
7.	MEN231	Energy Laboratory – II	0	0	3	1
		TOTAL	**18**	**1**	**3**	**20**

SEMESTER III

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
1	E5	Elective V	3	0	0	3
2	E6	Elective VI	3	0	0	3
3	E7	Elective VII	3	0	0	3
PRACTICAL						
4	MEN331	Project work - Phase I	0	0	12	6
5	MEN332	Industrial Training Practice	0	0	0	1
		TOTAL	**9**	**0**	**12**	**16**
Phase I: Review of Literature, Problem Identification, Methodology, Work Plan, Preparation and Presentation.						

Industrial Training Practice : A training of 15 days duration on the practical aspects of various energy technologies will be carried out by the students after the completion of Second Semester during Summer Vacation, at Energy Industry / Energy Projects / Energy Centers / R & D Institutions / Research Laboratories etc. which will be evaluated during this Semester and it is evaluated by Internal Examiner.

SEMESTER IV

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL						
1	MEN431	Project work - Phase II	0	0	24	12
		TOTAL	**0**	**0**	**24**	**12**
Phase II: Analysis, Presentation and Viva						
					Total Credits	**69**

TOTAL CREDITS TO BE EARNED FOR THE AWARD OF THE DEGREE - 69

NATIONAL ENGINEERING COLLEGE, K.R.NAGAR, KOVILPATTI

(An Autonomous Institution Affiliated to Anna University Chennai)

M.E. (ENERGY ENGINEERING)

CURRICULUM I TO VI SEMESTERS (PART TIME)

SEMESTER - I (Part time)

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	MEN101	Thermodynamics and Thermal Systems	3	1	0	4
2	MEN102	Fuels and Combustion Technology	3	1	0	4
3	MEN103	Energy Conversion Systems	3	0	0	3
PRACTICAL						
4	MEN131	Energy Laboratory – I	0	0	3	1
		TOTAL	**9**	**2**	**3**	**12**

SEMESTER - II (Part time)

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	MEN201	Design and Optimization of Energy Systems	3	1	0	4
2	MEN202	Energy Audit and Management	3	0	0	3
3	MEN203	Analysis of Power Plants	3	0	0	3
PRACTICAL						
4	MEN231	Energy Laboratory – II	0	0	3	1
		TOTAL	**9**	**1**	**3**	**11**

SEMESTER - III (Part time)

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	MEN104	Non-Conventional Sources of Energy	3	0	0	3
2	MEN105	Environmental Impact of Energy Systems	3	0	0	3
3	E1	Elective I	3	0	0	3
		TOTAL	**9**	**0**	**0**	**9**

SEMESTER - IV (Part time)

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	E2	Elective II	3	0	0	3
2	E3	Elective III	3	0	0	3
3	E4	Elective IV	3	0	0	3
		TOTAL	**9**	**0**	**0**	**9**

SEMESTER - V (Part time)

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	E5	Elective V	3	0	0	3
2	E6	Elective VI	3	0	0	3
3	E7	Elective VII	3	0	0	3
PRACTICAL						
4	MEN331	Project work - Phase I	0	0	12	6
5	MEN332	Industrial Training Practice	0	0	0	1
		TOTAL	**9**	**0**	**12**	**16**

Phase I: Review of Literature, Problem Identification, Methodology, Work Plan, Preparation and Presentation.

Industrial Training Practice : A training of 15 days duration on the practical aspects of various energy technologies will be carried out by the students after the completion of Fourth Semester during Summer Vacation, at Energy Industry / Energy Projects / Energy Centers / R & D Institutions / Research Laboratories etc. which will be evaluated during this Semester and it is evaluated by Internal Examiner.

SEMESTER VI (Part time)

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL						
1	MEN431	Project work - Phase II	0	0	24	12
		TOTAL	**0**	**0**	**24**	**12**

Phase II: Analysis, Presentation and Viva

TOTAL CREDITS TO BE EARNED FOR THE AWARD OF THE DEGREE – 69

ELECTIVES FOR M.E ENERGY ENGINEERING						
S.NO	**COURSE CODE**	**COURSE TITLE**	**L**	**T**	**P**	**C**
1	MEN001	Advanced Fluid Mechanics	3	0	0	3
2	MEN002	Conventional Energy Systems	3	0	0	3
3	MEN003	Environmental Engineering and Pollution Control	3	0	0	3
4	MEN004	Energy Conservation and Management	3	0	0	3
5	MEN005	Bio Energy Engineering	3	0	0	3
6	MEN006	Solar Energy Systems	3	0	0	3
7	MEN007	Cogeneration and Waste Heat Recovery Systems	3	0	0	3
8	MEN008	Advanced Thermal Storage Technologies	3	0	0	3
9	MEN009	Alternative Fuels	3	0	0	3
10	MEN010	Waste Management And Energy Recovery	3	0	0	3
11	MEN011	Steam Generator Technology	3	0	0	3
12	MEN012	Materials for Energy Applications	3	0	0	3
13	MEN013	Energy Management and Economics	3	0	0	3
14	MEN014	Solar Architecture	3	0	0	3
15	MEN015	Design of Heat Exchangers	3	0	0	3
16	MEN016	Wind Energy Engineering	3	0	0	3
17	MEN017	Electrical Drives and Controls	3	0	0	3
18	MEN018	Fluidized Bed Systems	3	0	0	3
19	MEN019	Hydro Power Technology	3	0	0	3
20	MEN020	Nuclear Engineering	3	0	0	3
21	MEN021	Advanced Heat Transfer	3	0	0	3
22	MEN022	Instrumentation and Control Systems for Thermal Systems	3	0	0	3
23	MEN023	Solar Refrigeration and Air conditioning	3	0	0	3
24	MEN024	Computational Fluid Dynamics	3	0	0	3
25	MEN025	Fuel Cells and Hydrogen Energy	3	0	0	3

MEN101 THERMODYNAMICS AND THERMAL SYSTEMS

L	T	P	C
3	1	0	4

UNIT I **10**

Basic Concepts of Thermodynamics, Thermodynamics Laws, Entropy: Entropy as a property, Combined First and Second Law, Increase of Entropy Principle, Entropy Change of a Pure Substance , Liquid and solids, Efficiency of devices, Availability - irreversibility and second – law efficiency for a closed system and steady – state control volume. Availability analysis of simple cycles.

UNIT II **10**

Properties of steam, phase change process, Rankine cycle, Deviation of Actual Vapor Power Cycles from Idealized Ones, Reheat cycle, Regenerative cycle, Second-Law Analysis of Vapor Power Cycles.

UNIT III **08**

Refrigerators and Heat Pumps, The Reversed Carnot Cycle, The Ideal Vapor-Compression Refrigeration Cycle, Actual Vapor-Compression Refrigeration Cycle, Selecting the Right Refrigerant, Heat Pump Systems, Innovative Vapor-Compression Refrigeration Systems, Gas Refrigeration Cycles, Absorption Refrigeration Systems.

UNIT IV **10**

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. Periodic heat conduction. Quantitative analysis of heat transfer co-efficient for all the modes of heat transfer.

UNIT V **07**

Different types of heat exchangers, arithmetic and logarithmic mean temperature differences, heat transfer coefficient for parallel, counter and cross flow type heat exchanger; effectiveness of heat exchanger, N.T.U. method, fouling factor. Constructional and manufacturing aspects of Heat Exchangers.

Tutorial: 15 Periods **Total: 60 Periods**

REFERENCES

1. R. K. Rajput, Thermal Engineering, Laxmi Publications, Ltd., 2010
2. A.Faghri, JHowell, Y Zhang, Advanced Heat and Mass Transfer, Global Digital Press, 2010
3. P.K.Nag, Engineering Thermodynamics-Fourth Edition, Tata McGraw-Hill, 2008
4. Y.A Cengel, M.A.Boles, Thermodynamics: An Engineering Approach 6th edition Mcgraw-Hill Series 2007
5. Bejan.A, Advanced Engineering Thermodynamics-3rd Edition, John Wiley and Cons, 2006.
6. Arora.C.P, Thermodynamics, Tata McGraw-Hill Education, 2001
7. Frank Kreith., The CRC handbook of thermal engineering, Springer, 2000.

MEN102 FUELS AND COMBUSTION TECHNOLOGY **L T P C**
3 1 0 4

UNIT I **09**

Fuels & Fuel Analysis-Combustion Stoichiometry, theoretical & actual combustion processes – Air fuel ratio.

UNIT II **10**

Combustion Thermodynamics- calculation of heat of formation & heat of combustion – First Law analysis of reacting systems – Kinetic Reaction – Adiabatic Flame Temperature.

UNIT III **09**

Heat Treatment Furnaces- Industrial furnaces – process furnaces – Kilns – Batch & Continuous furnaces

UNIT IV **09**

Flame, Flame Structure, Ignition and Igniters – flame propagation – deflagration – detonations - flame front – Ignition – self & forced ignition – Ignition temperature.

UNIT V **08**

Combustion Appliances- Gas burners- Functional requirement of burners – Gas burner Classification –Stoker firing –pulverized system of firing – Fluidized Bed Combustion.

Tutorial: 15 Periods **Total: 60 Periods**

REFERENCES

1. Dr. Samir Sarkar, "Fuels & Combustion", University Press, 3rd edition, 2009.
2. Irvin Glassman, Richard A. Yetter , 4th Edition, Academic Press, 2008.
3. Mishra , Fundamentals of Combustion, PHI Learning Pvt. Ltd., 2008.
4. Cleveland, Cutler J Encyclopedia of Energy, Elsevier Publications, 2004
5. Principles of Combustion by Kenneth K. Kou – John Wiley, 2005
6. Blokh A.G, "Heat Transmission in Steam Boiler furnaces", Hemisphere Publishing, 1988.
7. S.P. Sharma & Chander Mohan, "Fuels & Combustion", Tata McGraw Hill Publishing Co. Ltd., 1984

MEN103 ENERGY CONVERSION SYSTEMS **L T P C**
3 0 0 3

UNIT – I ENERGY SOURCES **9**

Energy classification – Energy sources – Principal sources of energy: conventional and non conventional sources – bio-mass, fossil fuels, nuclear fuels, solar energy – Energy conversion –prospecting, extraction, resource assessment and their peculiar characteristics.

UNIT – II ENERGY CONVERSION IN THERMAL SYSTEM **10**

Production of thermal energy using bio-mass, fossil fuels, nuclear fuels, solar energy – Conversion of thermal energy, electrical energy, electromagnetic energy and hydraulic energy into mechanical energy – Energy conversion system: steam turbines, hydraulic turbines and wind turbines – Energy conversion system cycles.

UNIT – III ELECTRICAL ENERGY GENERATION **10**

Production of electrical energy using thermal energy, chemical energy, electromagnetic energy and mechanical energy – Magneto hydrodynamic conversion – introduction – MHD plasmas – analysis of MHD generators – MHD power applications – Batteries – basic concepts – electrochemical principles and reactions – selection and application of batteries – fuel cells – general characteristics – low power fuel cell systems – fuel cell power plants.

UNIT – IV ENERGY CONVERSION IN RENEWABLE ENERGY SYSTEMS **8**

Production of electrical energy using non-conventional sources: solar energy, wind energy, wave energy, tidal energy and ocean thermal energy. Solar thermal energy conversion system –photovoltaic conversion – optical effects of p-n junction – analysis of PV cells – wave energy conversion system – tidal energy conversion system – wind energy conversion system.

UNIT – V ENERGY STORAGE **7**

Energy storage: requirements and methods – storage of thermal energy – storage of mechanical energy – storage of electrical energy – storage of chemical energy – storage of nuclear energy.

TOTAL: 45 PERIODS

REFERENCES:

1. Homas Reddy, David Linden., - Handbook of Batteries,4th Edition, McGraw-Hill, 2010
2. Ahmed F. Zobaa, Ramesh Bansal ,- Handbook of Renewable Energy Technology, World Scientific Pub Co Inc, 2010
3. Peter Würfel, Uli Würfel - Physics of Solar Cells: From Basic Principles to Advanced Concepts, 2nd Edition, Wiley-VCH, 2009
4. W Vielstich, H Yokokawa, H A Gasteiger - Handbook of fuel cells- part 1, Volume 5, John Wiley and Sons, 2009
5. D. Yogi Goswami, Frank Kreith - Direct Energy Conversion, CRC Press, 2008
6. Cleveland, Cutler J Encyclopedia of Energy, Elsevier, 2004.
7. Culp, A.W., - Principles of energy conversion, Tata McGraw Hill, 2001
8. Messerle, Hugo K., - Magnetohydrodynamic Electric Power Generation, J. Wiley, 1995
9. IEEE Journals for Power, Energy, & Industry Applications

MEN104 NON-CONVENTIONAL SOURCES OF ENERGY **L T P C**
3 0 0 3

UNIT-I BIO-FUELS **9**

Bio-fuels classification -biomass production for energy forming - Energy through fermentation -Pyrolysis - Gasification and combustion, biogas, aerobic and anaerobic bio conversion process, feed stock, properties of biogas composition, biogas plant design and operation-Alcoholic fermentation.

UNIT-II HYDROGEN ENERGY **9**

Electrolytic and thermo chemical hydrogen production - Metal hydrides and storage of hydrogen -Hydrogen energy conversion systems, hybrid systems, - economics and technical feasibility.

UNIT-III SOLAR ENERGY **9**

Solar energy, photovoltaic and thermal applications, rural application, limitation of thermal energy.

UNIT-IV OCEAN THERMAL ENERGY CONVERSION **9**

Geothermal, Wave and tidal energy, availability, geographical distribution, Power generation using OTEC, wave and tidal energy, Scope and economics, Geothermal energy, availability, limitations.

UNIT-V WIND ENERGY **9**

Wind energy, General considerations, Wind Power plant design, Choice of power plant, Wind mapping and selection of location.Cost analysis and economics of systems utilizing renewable sources of energy.

Total: 45 Periods

REFERENCES:

1. Environmental and Water Resources Institute (U.S.). Bioenergy and Biofuel Task Committee- Bioenergy and Biofuel from Biowastes and Biomass- ASCE Publications, 2010
2. B.H Khan, Non Conventional Energy Resources, 2rd Edition, Tata McGraw Hill, 2009.
3. Sukhatme, S.P& J.K.Nayak, Solar Energy, 3rd Edition,Tata McGraw Hill, 2008
4. Twidell, J.W. and Weir, A., Renewable Energy Sources, 2nd Edition, Taylor & Francis, 2006.
5. S Srinivasan, Fuel cells: from fundamentals to applications, Springer, 2006.
6. B. T. Nijaguna, Biogas Technology - New Age International, 2006.
7. Cleveland, Cutler J Encyclopedia of Energy, Elsevier, 2004
8. IEEE Journals for Power, Energy, & Industry Applications

MEN105 ENVIRONMENTAL IMPACT OF ENERGY SYSTEMS **L T P C**
3 0 0 3

UNIT I ENVIRONMENTAL IMPACTS **9**

Environmental degradation due to energy production and utilization-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 II POLLUTION: THERMAL PLANTS **9**

Pollution due to thermal power station and its control and systems

UNITIII POLLUTION: NUCLEAR & HYDRO PLANTS **9**

Pollution due to nuclear power generation, radioactive waste and its disposal. Effect of Hydro electric power stations on ecology and environment.

UNIT IV INDUSTRIAL WASTE **9**

Industrial waste, Waste and effluent treatment-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 GLOBAL ENVIRONMENTAL CONCERN **9**

United Nations Framework Convention on Climate Change (UNFCC)-Protocol, Conference of Parties (COP)-Clean Development Mechanism (CDM), Prototype Carbon Funds-Carbon Credits and its trading, Benefits to developing countries, Building a CDM Project

Total: 45 Periods

REFERENCES

1. Steve Doty, Wayne C. Turner, Energy management handbook, 7th Edition, The Fairmont Press, Inc., 2009.
2. Abbi, Handbook on Energy Audit and Environment Management, TERI Press, 2006
3. Pierre André, Claude E. Delisle, Jean-Pierre Revéret, Environmental Assessment for Sustainable Development, Presses inter Polytechnique, 2004
4. Barbara Carroll, Trevor Turpin, Environmental impact assessment handbook, Thomas Telford, 2002
5. Robert A. Ristinen, Jack J. Kraushaar, Energy and the environment, Wiley, 1999

MEN131 ENERGY LABORTARY – I **L T P C**
0 0 3 1

RENEWABLE ENERGY **27**

1. Performance testing of Solar Water Collector
2. Characteristics of Solar photovoltaic devices
3. Testing of Gasifier
4. Testing of biogas plant
5. Properties of Fuels
6. Solar Radiation measurement
7. Performance testing of Solar Air Heater
8. Performance testing of Solar Still
9. Performance Study on Concentric Collectors

ENERGY CONSERVATION **12**

1. Boiler efficiency testing
2. Heat Exchangers
3. Energy consumption measurement of lighting systems
4. Refrigeration and Air conditioning systems

ADVANCED ENERGY SYSTEMS **6**

Thermal Storage Systems

TOTAL: 45 PERIODS

MEN201 DESIGN AND OPTIMIZATION OF ENERGY SYSTEMS **L T P C**
3 1 0 4

UNIT I INTRODUCTION **09**

Engineering Design- Design as Part of Engineering Enterprise- Thermal Systems

UNIT II BASIC CONSIDERATIONS IN DESIGN **09**

Formulation of the Design Problem- Conceptual Design- Steps in the Design Process- Computer-Aided Design of Thermal Systems- Material Selection

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.

Tutorial: 15 Periods **Total: 60 Periods**

REFERENCES

1. Jasbir Arora , Introduction to optimum design, 3rd Edition, Elsevier Science & Technology, 2011
2. William S. Janna, Design of Fluid Thermal Systems, 3rd Edition, Cengage Learning, 2010
3. Yogesh Jaluria, Design and optimization of thermal systems, 2nd Edition, CRC Press, 2007
4. Kalyanmoy Deb Optimization for engineering design: algorithms and examples, PHI Learning Pvt. Ltd., 2004.
5. IEEE Journals for Power, Energy, & Industry Applications

MEN202 ENERGY AUDIT AND MANAGEMENT **L T P C**
3 0 0 3

UNIT I **9**

Energy Scenario - Role of Energy Managers in Industries – Energy monitoring, auditing & targeting – Economics of various Energy Conservation schemes. Total Energy Systems

UNIT II **9**

Energy Audit -various Energy Conservation Measures in Steam -Losses in Boiler. Energy Conservation in Steam Systems -Case studies.

UNIT III **9**

Energy conservation in Centrifugal pumps, Fans & Blowers, Air compressor – energy consumption & energy saving potentials – Design consideration.

UNIT IV **9**

Refrigeration & Air conditioning - Heat load estimation -Energy conservation in cooling towers & spray ponds – Case studies Electrical Energy -Energy Efficiency in Lighting – Casestudies.

UNIT V **9**

Organizational background desired for energy management motivation, detailed process of M&T-Thermostats, Boiler controls- proportional, differential and integral control, optimizers; compensators.

Total: 45 Periods

REFERNECES

1. Steve Doty, Wayne C. Turner Energy management handbook, 7th Edition, the Fairmont Press, Inc., 2009.
2. D P Kothari, I J Nagrath ,Power System Engineering 2nd Ed., Tata McGraw-Hill Education, 2008
3. K. Nagabhushan Raju, Industrial Energy Conservation Techniques, Atlantic Publishers & Dist, 2007
4. Eastop T.D & Croft D.R, Energy Efficiency for Engineers and Technologists Longman Scientific & Technical, 1990.

MEN203 ANALYSIS OF POWER PLANTS L T P C
3 0 0 3

UNIT I INTRODUCTION 7

Introduction to economics of power generation. Load duration curves, location of power plants, power plant economics, Indian energy scenario.

UNIT II ANALYSIS OF STEAM POWER PLANTS (SPP) 10

Components of steam power plants, Effect of variations, variation of steam condition on thermal efficiency of steam power plant. Typical layout of SPP. Efficiencies in a SPP.

UNIT III ANALYSIS OF HYDROELECTRIC POWER PLANTS (HEPP) 8

Components of HEPP, Types of turbine- Pelton, Francis, Kaplan, Propeller, Deriaz and Bulb turbines, Typical layout of HEPP, Performance of turbinesand comparison.

UNIT IV ANALYSIS OF DIESEL AND GAS TURBINE POWER PLANTS 10

General layout of Diesel and Gas Turbine power plants, Performance of Diesel and Gas Turbine power plants, comparison with other types of power plants.

UNIT V NUCLEAR AND MHD POWER PLANTS 10

Overview of Nuclear power plants - radioactivity - fission process- reaction rates - diffusion theory, elastic scattering and slowing down - criticality calculations – critical heat flux - power reactors - nuclear safety. MHD and MHD - steam power plants.

Total: 45 Periods

REFERENCES:

1. R.Kehlhofer, B.Rukes, F.Hannemann, F.Stirnimann Combined-cycle gas & steam turbine power plants, 3rd Edition, PennWell Books, 2009
2. Nag, P.K., Power Plant Engineering, 3rd Edition,Tata McGraw-Hill Education, 2008.
3. Arora and Domkundwar, A course in power Plant Engineering, Dhanpat Rai and CO, 2004.
4. RR.Gay, C. A. Palmer, M.R.Erbes Power Plant Performance Monitoring, R-Squared Publishing, 2004
5. Philip Kiameh., Power generation handbook, McGraw-Hill, 2003
6. Lamarsh, J.R., Introduction to Nuclear Engineering, 3rd edition, Prentice Hall, 2001

MEN231 ENERGY LABORATORY – II **L T P C**
0 0 3 1

I Cycle **24** Periods

1. Steady State Conduction in Solid
2. Steady State Convection in Solid
3. Steady State Radiation in Solid
4. Combined conduction and convection
5. Unsteady state conduction and convection
6. Unsteady state conduction and radiation

II Cycle **21Periods**

1. Steady state conduction in Fluids
2. Steady state convection in Fluids
3. Two-phase flows
4. Condensation and boiling heat transfer
5. Solar Radiation Model
6. Energy system simulations

TOTAL: 45 PERIODS

ELECTIVE PAPERS

MEN001 ADVANCED FLUID MECHANICS

L	T	P	C
3	0	0	3

UNIT - I **9**

Kinematics of fluid flow - introduction – regimes of fluid mechanics - Lagrangian and Eulerian approach - revision of concepts of different types of fluids, stream lines, path lines, velocity potentials, vorticity – substantial derivative – equations of continuity – Euler's equation – Bernoulli's equations for ideal fluid flow - flow past circular cylinder with and without circulation – flow past an aerofoil.

UNIT - II **9**

Viscous flow - stress components in real fluids – stress analysis on fluid motions – Navier Stokes equation of motion – energy equation – properties of Navier Stokes equation – exact solution of Navier Stokes equation for flow between parallel plates – couette flow – flow through pipes – flow between two concentric rotating cylinders.

UNIT - III **9**

Laminar boundary layer - laminar boundary layer equation – similarity solution for steady two dimensional flow – approximate integral method – numerical solutions - boundary layer control.

UNIT - IV **9**

Turbulence - introduction to onset of turbulence – physical and mathematical description of turbulence – Reynolds equation for turbulent motion – semi empirical theories of turbulence – turbulent flow through pipes – turbulent boundary layer equations - turbulent flow with zero pressure gradient on smooth flat plate and rough flat plate.

UNIT – V **9**

Compressible flow - fundamental equation of flow of compressible viscous and inviscid fluid – plane couette flow – exact solution – steady flow through constant area pipe – laminar boundary layer equation in compressible flow – boundary layer with pressure gradient and with zero pressure gradient – application of moment integral equation to boundary layers – turbulent boundary layer equations in compressible flow – compressible turbulent flow past a flat plate.

TOTAL: 45 PERIODS

REFERENCES:

1. Fox, R. W. and McDonald, A. T., 8th Edition, Intoduction to Fluid Mechanics, John Wiley & Sons, 2010.
2. W. P. Graebel , Advanced Fluid Mechanics – Academic Press, 2007
3. White, F. M., Viscous Fluid Flow – 3 Edition, McGraw-Hill Higher Education, 2006
4. Muralidhar, K. and G. Biswas,2nd Edition, Advanced Engineering Fluid Mechanics, Alpha Science International, 2005
5. G. Biswas., Introduction to fluid mechanics and fluid machines, 2nd Edition, Tata McGraw-Hill Education, 2003
6. Schlichting, H. and Gersten, K., Boundary Layer Theory - 8/e, Springer, 2000

MEN002 CONVENTIONAL ENERGY SYSTEMS **L T P C**
3 0 0 3

UNIT I HYDRO ELECTRIC STATIONS **9**

Selection of site, Essential features and elements, Principal Auxiliaries, Plant Layout, Classification of Hydro power plants, Hydraulic Turbines, Water wheel Generators.

UNIT II THERMAL POWER STATIONS 9

Selection of site for Coal fired power plants, Essential features and elements, Principal Auxiliaries, Plant Layout, Steam Turbines, Turbo Alternators. Gas Electric power plants, Diesel Electric power plants.

UNIT III NUCLEAR POWER STATIONS 9

Fission and fusion technology fundamentals. Basic construction and comparison of various types of nuclear reactors, Plant Layout, Risks and Safety measures. Comparison of various conventional energy systems, their prospects and limitations.

UNIT IV ECONOMIC ASPECTS OF POWER PLANT OPERATION 9

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, time value of money, types of interests, inflation, interest formulae relating present and future worth of single amount. Pay back period and Net-present value methods to assess financial efficiency of power plants.

UNIT V DEMAND SIDE LOAD MANAGEMENT 9

Concepts, Barriers, Planning and Implementation methods etc.

TOTAL: 45 PERIODS

REFERENCES

1. J.B. Gupta , A Course In Electrical Power , S. K. Kataria & Sons, 2009
2. V.K. Mehta, Rohit Mehta, Principles Of Power System (M.E.), 4th Edition, S. Chand, 2006
3. R.K. Rajput, A Textbook of Power Plant Engineering , Laxmi Publications, 2005
4. TC Kandpal, H P Garg, Financial Evaluation of Renewable Energy Technologies, Macmillan Publishers India Ltd, 2003

MEN003 ENVIRONMENTAL ENGINEERING & POLLUTION CONTROL

L	T	P	C
3	0	0	3

UNIT I INTRODUCTION 9

Global atmospheric change – green house effect – Ozone depletion - natural cycles - mass and energy transfer – material balance – environmental chemistry and biology – impacts – environmental. Legislations.

UNIT II AIR POLLUTION 9

Pollutants - sources and effect – air pollution meteorology – atmospheric dispersion – indoor air quality - control methods and equipments - issues in air pollution control – air sampling and measurement.

UNIT III WATER POLLUTION 9

Water resources - water pollutants - characteristics – quality - water treatment systems – waste water treatment - treatment, utilization and disposal of sludge - monitoring compliance with standards.

UNIT IV WASTE MANAGEMENT 9

Sources and Classification – Solid waste – Hazardous waste - Characteristics – Collection and Transportation - Disposal – Processing and Energy Recovery – Waste minimization.

UNIT V OTHER TYPES OF POLLUTION FROM INDUSTRIES 9

Noise pollution and its impact - oil pollution - pesticides - instrumentation for pollution control - water pollution from tanneries and other industries and their control – environment impact assessment for various projects – case studies.

TOTAL: 45 PERIODS

REFERENCES

1. Gilbert M. Masters, “Introduction to Environmental Engineering and Science”, 3rd Edition, Prentice Hall, 2008.
2. N.L. Nemerow, F.J. Agardy., “Environmental Engineering”, 6th Edition,John Wiley and Sons, 2008
3. Gerard Kiely, Environmental engineering, Tata McGraw-Hill Education, 2007
4. Rao C .S . "Environmental Pollution Control Engineering,” 2nd Edition, New Age International Publishers, 2006.
5. Arcadio P Sincero and G. A. Sincero, Environmental Engineering – A Design Approach, Prentice Hall of India Pvt Ltd, New Delhi, 2002.
6. Bishop P., Pollution Prevention: Fundamentals and Practice, McGraw-Hill International Edition, McGraw-Hill book Co, Singapore, 2000

MEN004 ENERGY CONSERVATION AND MANAGEMENT L T P C
3 0 0 3

UNIT I INTRODUCTION 8

Energy Scenario - Principles and Imperatives of Energy Conservation - Energy Consumption Pattern – Resource Availability - Role of Energy Managers in Industries

UNIT II THERMAL ENERGY AUDITIING 12

Energy Audit-Purpose, Methodology with respect to process Industries - Power plants, Boilers etc., -Characteristic method Employed in Certain Energy Intensive Industries - Various Energy Conservation Measures in Steam System - Losses in Boiler, Methodology of Upgrading Boiler Performance Energy conservation in pumps, Fans & Compressors, Air conditioning and refrigeration systems, Steam Traps- Types, Function, Necessity

UNIT III ROLE OF INSTRUMENTATION IN ENERGY CONSERVATION 10

Total Energy systems - Concept of Total Energy - Advantages & Limitations - Total Energy system & Application - Various Possible Schemes Employing Steam Turbines Movers Used in Total Energy Systems - Potential & Economics of Total Energy Systems

UNIT IV ELECTRICAL ENERGY AUDITING 10

Potential Areas for Electrical Energy Conservation in Various Industries-Energy Management Opportunities in Electrical Heating, Lighting system, Cable selection - Energy Efficient Motors - Factors involved in Determination of Motor Efficiency Adjustable AC Drives, Applications & its use variable speed Drives/Belt Drives

UNIT V ENERGY MANAGEMENT 5

Importance of Energy Management, Energy Economics - Discount Rate, Payback Period, Internal Rate of Return, Life Cycle Costing

Total: 45 Periods

REFERENCES:

1. Steve Doty, Wayne C. Turner Energy management handbook, 7th Edition, The Fairmont Press, Inc., 2009.
2. B.L.Capehart, W.C.Turner, W.J. Kennedy, Guide to energy management: international version, 5th Edition, The Fairmont Press, Inc., 2008.
3. F Kreith, D. Y Goswami, Energy management and conservation handbook, CRC Press, 2008
4. A.Thumann, W.J. Younger, Handbook of energy audits; 6th Edition, Fairmont Press, 2003.
5. C.Beggs, Energy: management, supply and conservation,2nd Edition, Butterworth - Heinemann Publications, 2002

MEN005 BIO ENERGY ENGINEERING **L T P C**
3 0 0 3

UNIT – I 9

Sources and Classification. Chemical composition, properties of biomass. Energy plantations.Size reduction, Briquetting, Drying, Storage and handling of biomass.

UNIT- II 9

Feedstock for biogas, Microbial and biochemical aspects- operating parameters for biogas production. Kinetics and mechanism- High rate digesters for industrial waster water treatment.

UNIT- III 9

Thermo chemical conversion of lignocelluloses biomass. Incineration, Processing for liquid fuel production. Pyrolysis -Effect of particle size, temperature, and products obtained.

UNIT- IV 9

Thermo chemical Principles: Effect of pressure, temperature , steam and oxygen. Fixed and fluidized bed Gasifiers- Partial gasification of biomass by CFB.

UNIT-V 9

Combustion of woody biomass-Design of equipment. Cogeneration using bagasse - Case studies: Combustion of rice husk.

Total: 45 Periods

REFERENCES

1. A.A. Vertès, N Qureshi, H Yukawa, Biomass to biofuels: strategies for global industries, John Wiley and Sons, 2009
2. J D. Wall, C S. Harwood, A L. Demain , Bioenergy, ASM Press, 2008
3. D.M. Mousdale, Biofuels, CRC Press, 2008
4. Nijaguna, B.T., Biogas Technology, New Age International publishers (P) Ltd., 2006
5. Rezaiyan. J and N. P. Cheremisinoff, “Gasification Technologies, A Primer for Engineers and Scientists”, Taylor & Francis, 2005
6. D. Yogi Goswami, Frank Kreith, Jan. F .Kreider, “Principles of Solar Engineering”, 2nd Edition, Taylor & Francis,2003
7. NIIR Board, Hand book on bio gas and it's applications, National Institute Of Industrial Re, 2000
8. IEEE Journals for Power, Energy, & Industry Applications

MEN006 SOLAR ENERGY SYSTEMS L T P C
3 0 0 3

UNIT - I SOLAR RADIATION 8

Source of radiation – Sun earth relationship- extra terrestrial radiation.– Atmospheric attenuation – Terrestrial radiation-radiation on a horizontal surfaces and inclined planes relations between horizontal radiation and inclined surfaces – relations between monthly, daily and hourly radiation and components of the radiations– solar charts – Critical radiation-Measurement of global, direct and diffuse solar radiation- pyroheliometer, pyrano meter, pyro geo meter, net pyradiometer-sunshine recorder – an overview of solar radiation data in India..

UNIT II SOLAR COLLECTORS 10

Design considerations – classification- Flat plate collectors- air heating collectors liquid heating –Temperature distributions- Heat removal rate- Useful energy gain – Losses in the collectors-for efficiency of flat plate collectors – selective surfaces – tubular solar energy collectors analysis of concentric tube collector – testing of flat plate collectors. Solar green house. Concentric collectors-Limits to concentration – concentrator mounting – tracking mechanism - performance analysis focusing solar concentrators: Heliostats.

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UNIT III SOLAR CELLS 9

Conversion of Solar energy into Electricity - Photovoltaic Effect, Equivalent Circuit of the Solar Cell, Analysis of PV Cells: Dark and illumination characteristics, Figure of merits of solar cell, Efficiency limits, Variation of efficiency with band-gap and temperature, Efficiency measurements, High efficiency cells, Recent developments in Solar Cells, Role of nano-technology in Solar cells.

UNIT IV SOLAR PHOTOVOLTAIC SYSTEM DESIGN 10

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, Voltage regulation, Maximum tracking, Quick sizing method, Array protection.

UNIT V INDUSTRIAL APPLICATIONS OF SOLAR HEAT 8

Temperature requirements, consumption pattern, Solar Passive Heating and Cooling, Solar Thermal Power Plant, Modeling of Solar Thermal Systems, Solar Desalination, Solar Drying, Solar Cooking, Solar Greenhouse technology: Fundamentals, design, modeling and applications in agriculture and space heating

TOTAL: 45 PERIODS

REFERENCES

1. L D. Partain, L M. Fraas, Solar Cells and Their Applications, 2nd Edition, John Wiley and Sons, 2010
2. Soteris Kalogirou, Solar energy engineering, Academic Press, 2009
3. Sukhatme S P, Solar Energy, 3rd Edition, Tata McGraw-Hill Education, 2008
4. Duffie, J. A. and Beckman, W. A., Solar Engineering of Thermal Processes,3rd Edition, Wiley, 2006
5. A Luque, S Hegedus, Handbook of photovoltaic science and engineering, John Wiley and Sons, 2003
6. G. N. Tiwari, Solar energy, CRC Press, 2002
7. IEEE Journals for Power, Energy, & Industry Applications

MEN007 COGENERATION AND WASTE HEAT RECOVERY SYSTEMS

L T P C
3 0 0 3

UNIT I INTRODUCTION 9

Introduction - principles of thermodynamics – cycles - topping - bottoming – combined cycle - organic rankine cycles – performance indices of cogeneration systems – waste heat recovery – sources and types – concept of tri generation.

UNIT II COGENERATION TECHNOLOGIES 9

Configuration and thermodynamic performance – steam turbine cogeneration systems – gas turbine cogeneration systems – reciprocating IC engines cogeneration systems – combined cycles cogeneration systems – advanced cogeneration systems: fuel cell, Stirling engines etc.,

UNIT III ISSUES AND APPLICATIONS OF COGENERATION TECHNOLOGIES 9

Cogeneration plants electrical interconnection issues – utility and cogeneration plant interconnection issues – applications of cogeneration in utility sector – industrial sector – building sector – rural sector – impacts of cogeneration plants – fuel, electricity and environment

UNIT IV WASTE HEAT RECOVERY SYSTEMS 9

Election criteria for waste heat recovery technologies - recuperators - Regenerators - economizers - plate heat exchangers – Thermic fluid heaters - Waste heat boilers classification, location, service conditions, design Considerations - fluidized bed heat exchangers - heat pipe exchangers - heat pumps – sorption systems.

UNIT V ECONOMIC ANALYSIS 9

Investment cost – economic concepts – measures of economic performance – procedure for economic analysis – examples – procedure for optimized system selection and design – load curves - sensitivity analysis – regulatory and financial frame work for cogeneration and waste heat recovery systems.

TOTAL: 45 PERIODS

REFERENCES

1. R.Kehlhofer, B. Rukes, F. Hannemann, F. Stirnimann, Combined - cycle gas & steam turbine power plants,3rd Edition, PennWell Books, 2009.
2. Steve Doty, Wayne C. Turner, Energy management handbook,7th Edition, The Fairmont Press, Inc., 2009
3. A.Thumann, D. Paul Mehta, Handbook of energy engineering, 6th Edition, The Fairmont Press, Inc., 2008
4. B.F.Kolanowski, Small-scale cogeneration handbook, 2nd Edition, Fairmont Press, 2003
5. M.P. Boyce, Handbook for cogeneration and combined cycle power plants, ASME Press, 2002
6. EDUCOGEN – The European Educational tool for cogeneration, Second Edition, 2001

MEN008 ADVANCED THERMAL STORAGE TECHNOLOGIES L T P C
3 0 0 3

UNIT I INTRODUCTION 8

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 9

Basic concepts and modeling of heat storage units - modeling of simple water and rock bed storage system – pressurized water storage system for power plant applications – packed beds.

UNIT III REGENERATORS 10

Parallel flow and counter flow regenerators – finite conductivity model – non – linear model – transient performance – step changes in inlet gas temperature – step changes in gas flow rate – parameterization of transient response – heat storage exchangers.

UNIT IV LATENT HEAT STORAGE SYSTEMS 9

Modeling of phase change problems – temperature based model - enthalpy model - porous medium approach - conduction dominated phase change – convection dominated phase change.

UNIT V APPLICATIONS 9

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

1. Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons 2010.
2. A Thumann, D. Paul Mehta , Handbook of energy engineering, 6th Edition, The Fairmont Press, Inc., 2008
3. Halime Ö Paksoy, Thermal energy storage for sustainable energy consumption, Springer, 2007
4. IEEE Journals for Power, Energy, & Industry Applications

MEN009 ALTERNATIVE FUELS **L T P C**
3 0 0 3

UNIT – I OVERVIEW **9**

Introduction – Alternative fuels – Potential solid - liquid - and gaseous fuels. – Alcohols – ethanol, methanol, M85, E85 and gashol – properties – SI engine combustion performance and emission characteristics. Alcohols for CI engine – Alcohol fumigation – Dual fuel injection – Surface ignition and spark ignition- storage, dispensing and safety – material compatibility.

UNIT – II VEGETABLE OILS AND OTHER SIMILAR FUELS DERIVED 9

Vegetable oils- properties – advantages and disadvantages – Biodiesel – trans - esterification -Factors affecting the process – Properties- Biodiesel blends – engine combustion, performance and emission characteristics- material compatibility , other alternative liquid fuels – benzol – acetone – diethyl ether.

UNIT – III NATUARAL GAS AND LPG **9**

Alternative gaseous fuels – natural gas and LPG – production – properties of natural gas and LPG – CNG conversion kits – Advantages and disadvantages of NG and LPG – comparison of gasoline and LPG – CNG and LPG fuel feed system – LPG & CNG for CI engine – methods of fuel induction engine combustion, performance and emission characteristics.

UNIT – IV HYDROGEN AS ALTERNATIVE FUEL **9**

Hydrogen energy – properties , production , thermo- chemical methods – Hydrogen storage – Delivery – conversion – safety – Hydrogen engines, methods of usage in SI and CI engine – Hydrogen injection system – Hydrogen induction in SI engine.

UNIT – V BIOGAS FOR IC ENGINES **9**

Biogas – properties – Biogas for running IC engine – Biogas as vehicle fuel – biogas consumption – engine performance and emission- Biomass gasification – producer gas – Consumption – dual fuel operation – engine performance and emission.

REFERENCES **TOTAL: 45 PERIODS**

1. D Tomes, P Lakshmanan., Biofuels: Global Impact on Renewable Energy, Production Agriculture, and Technological Advancements, Springer, 2010
2. Ram B. Gupta, Hydrogen fuel: production, transport, and storage, CRC Press, 2009
3. Ganesan.V, - Internal Combustion Engines, Tata McGraw-Hill Education, 2008
4. M.F. Hordeski, Alternative fuels: the future of hydrogen,2nd Edition, The Fairmont Press, Inc., 2008
5. Sunggyu Lee, J. G. Speight, S. K. Loyalka, Handbook of alternative fuel technologies, CRC Press, 2007.
6. B. T. Nijaguna, Biogas Technology, New Age International, 2006
7. IEEE Journals for Power, Energy, & Industry Applications.

MEN010 WASTE MANAGEMENT AND ENERGY RECOVERY L T P C
3 0 0 3

UNIT I SOLID WASTE – CHARACTERISTICS AND PERSPECTIVES 6

Definition - types – sources – generation and estimation. Properties: physical, chemical and biological – regulation

UNIT II COLLECTION, TRANSPORTATION AND PROCESSING TECHNIQUES 8

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 ENERGY GENERATION TECHNIQUES 16

Basics, types, working and typical conversion efficiencies of composting – anaerobic digestion – RDF – combustion – incineration – gasification – pyrolysis

UNIT IV HAZARDOUS WASTE MANAGEMENT 8

Hazardous waste – definition - potential sources - waste sources by industry – impacts – waste control methods – transportation regulations - risk assessment - remediation technologies – Private public partnership – Government initiatives.

UNIT V ULTIMATE DISPOSAL 7

Landfill – classification – site selection parameters – design aspects – Leachate control – environmental monitoring system for Land Fill Gases.

TOTAL: 45 PERIODS

REFERENCES

1. Michael D. Lagrega., et al., Hazardous Waste Management, Waveland Pr Inc, 2010
2. Paul T. Williams, Waste treatment and disposal, 2nd Edition, John Wiley and Sons, 2005
3. Velma I. Grover, Recovering energy from Science Publishers, 2002
4. Tchobanoglous, Theisen and Vigil, Integrated Solid Waste Management, Second Ed. McGraw-Hill, New York, 1993
5. Stanley E. Manahan. Hazardous Waste Chemistry, Toxicology and Treatment, Lewis Publishers, Chelsea, Michigan, 1990

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MEN011 STEAM GENERATOR TECHNOLOGY L T P C
3 0 0 3

UNIT I INTRODUCTION 10

Boilers – components - classification – general design considerations – boiler specifications. Fuel stoichiometry calculations – enthalpy calculation of air and combustion products – heat balance.

UNIT II COAL PREPARATION SYSTEM OF BOILERS 8

Pulverizing properties of coal – air system for pulverization – size – reducing machines. Design of coal preparation system for PC Boilers – fuel-feeding arrangements.

UNIT III DESIGN OF BURNERS 8

Design of oil supply system - tangential fired burners - oil atomizers - air registers - design principles of oil fired boilers.

UNIT IV BOILER FURNACE DESIGN 9

General design Principles – flame Emissivity – heat transfer calculation for PC Boiler furnace – water wall arrangement – furnace emissivity – distribution of heat load in furnace. Fluidized bed boilers - major features of fluidized bed boilers – basic design principles.

UNIT V DESIGN OF CONVECTIVE HEAT TRANSFER SURFACE 10

Design of economizer – superheater – reheater – air preheater. Temperature control in superheaters and reheaters.

TOTAL: 45 PERIODS

REFERENCES

1. Hubert Edwin Collins, Boilers Biblio Bazaar, 2009
2. D. Annaratone, Steam Generators: Description and Design, Springer, 2008
3. Wen-Ching Yang., Handbook of Fluidization and Fluid-Particle Systems, 2nd Edition, CRC Press, 2003
4. Ganapathy, V., Industrial Boilers and Heat Recovery Steam Generators, Marcel Dekker Ink 2003
5. Dennis R. Moss , Pressure vessel design manual,3rd Edition, Elsevier, 2004
6. Prabir Basu, Cen Kefa and Louis Jestin, Boilers and Burners: Design and Theory, Springer 2000.

MEN012 MATERIALS FOR ENERGY APPLICATIONS L T P C
3 0 0 3

UNIT I MATERIALS 9

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 9

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 9

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 9

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 FERRO ELECTRICITY 9

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

1. İbrahim Dinçer, Marc Rosen Thermal Energy Storage, 2nd Edition, John Wiley and Sons, 2010
2. WD Callister, Jr, Materials Science and Engineering: An Introduction, John Wiley, New York, 2010
3. Robert A. Huggins, Energy Storage, Springer, 2010
4. Srinivasan, Engg Materials And Mettalurgy,2nd Edition, Tata McGraw-Hill Education, 2010
5. A Ter-Gazarian, Energy Storage for Power Systems, Peter Peregrinus Ltd London, 1994
6. R Narayan, B Viswanathan, Chemical and Electrochemical Energy System, Universities Press,1998
7. IEEE Journals for Power, Energy, & Industry Applications

MEN013 ENERGY MANAGEMENT AND ECONOMICS L T P C
3 0 0 3

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.

TOTAL: 45 PERIODS

REFERENCES:

1. Michael Wickens Macroeconomic Theory: A Dynamic General Equilibrium Approach, Princeton University Press, 2009
2. YP Abbi and Shashank Jain. Handbook on Energy Audit and Environment Management, TERI Publications, 2006.
3. R Loulou, P R Shukla and A Kanudia, Energy and Environment Policies for a sustainable Future, Allied Publishers Ltd, New Delhi, 1997
4. J Parikh, Energy Models for 2000 and Beyond, Tata McGraw-Hill Ltd, New Delhi, 1997
5. P. O'Callaghan: Energy Management, McGraw - Hill Book Company, 1993
6. CB Smith, Energy Management Principles, Pergamon Press, NewYork, 1981

MEN014 SOLAR ARCHITECTURE L T P C
3 0 0 3

UNIT I INTRODUCTION 9

Bio-climatic classification of India, Passive Solar Passive Building and Green Building Concepts, National Building Code, Energy Star Rating , Policies on Energy Efficient and Green buildings

UNIT II PASSIVE HEATING & COOLING CONCEPTS 9

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 9

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 9

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 9

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

TOTAL: 45 PERIODS

REFERENCES

1. David Findley, Solar Power for Your Home, McGraw-Hill Professional, 2010
2. Jan F. Kreider, P Curtiss, Ari Rabl, Heating and cooling of buildings: design for efficiency, 2nd Edition, CRC Press, 2010.
3. Sue Reed, Energy-Wise Landscape Design, New Society Publishers, 2010
4. S Roaf, M Fuentes, S Thomas, Ecohouse: a design guide,3rd Edition, Architectural Press, 2007
5. Climatology, DS Lal, Sharda Pustak Bhawan, Allahabad, 2003
6. Christian Schittich, Solar architecture: strategies, visions, concepts, Edition Detail, 2003
7. Daniel D. Chiras, The solar house: passive heating and cooling, Chelsea Green Publishing, 2002
8. IEEE Journals for Power, Energy, & Industry Applications

MEN015 DESIGN OF HEAT EXCHANGERS **L T P C**
3 0 0 3

UNIT I FUNDAMENTALS OF HEAT EXCHANGER 9

Temperature distribution and its implications types – shell and tube heat exchangers – regenerators and recuperators – analysis of heat exchangers – LMTD and effectiveness method.

UNIT II FLOW AND STRESS ANALYSIS 9

Effect of turbulence – friction factor – pressure loss – stress in tubes – header sheets and pressure vessels – thermal stresses, shear stresses - types of failures.

UNIT III DESIGN ASPECTS 9

Heat transfer and pressure loss – flow configuration – effect of baffles – effect of deviations from ideality – design of double pipe - finned tube - shell and tube heat exchangers - simulation of heat exchangers.

UNIT IV COMPACT AND PLATE HEAT EXCHANGERS 9

Types – merits and demerits – design of compact heat exchangers, plate heat exchangers – performance influencing parameters - limitations.

UNIT V CONDENSERS AND COOLING TOWERS 9

Design of surface and evaporative condensers – cooling tower – performance characteristics.

TOTAL: 45 PERIODS

REFERENCES

1. R. W. Serth, Process heat transfer: principles and applications, Academic Press, 2007
2. R. K. Shah, D P. Sekulić, Fundamentals of heat exchanger design, John Wiley and Sons, 2003
3. Sadik Kakac and Hongtan Liu, Heat Exchangers Selection, Rating and Thermal Design, CRC Press, 2002
4. T. Kuppan, Heat exchanger design handbook, Marcel Dekker, 2000
5. IEEE Journals for Power, Energy, & Industry Applications

MEN016 WIND ENERGY ENGINEERING L T P C
3 0 0 3

UNIT I 9

Measurement and instrumentation – Beau fort number -Gust parameters – wind type – power law index -Betz constant -Terrain value.

UNIT II 9

Energy in wind– study of wind applicable Indian standards – Steel Tables, Structural Engineering

UNIT III 9

Variables in wind energy conversion systems – wind power density – power in a wind stream– wind turbine efficiency – Forces on the blades of a propeller – Solidity and selection curves.

UNIT IV 9

HAWT, VAWT– tower design-power duration curves- wind rose diagrams- study of characteristics - actuator theory- controls and instrumentations – Blade Element Theory

UNIT V 9

Grid-combination of diesel generator, Battery storage – wind turbine circuits- Wind farms—fatigue stress – Hybrid Systems

TOTAL: 45 PERIODS

REFERENCES

1. T Burton, et.al, Wind Energy Handbook,2nd Edition, John Wiley and Sons, 2011
2. J.F. Manwell, et.al, Wind Energy Explained,2nd Edition, John Wiley and Sons, 2009
3. D. A. Spera, Wind Turbine Technology: Fundamental concepts of Wind Turbine Engineering, 2nd Edition, ASME Press, 2009
4. William W. Peng, Fundamentals of turbomachinery, John Wiley and Sons, 2008
5. Mukund. R. Patel, Wind and solar power systems 2nd Edition, Taylor & Francis, 2006
6. S. Rao & B. B. Parulekar, “Energy Technology”, 4th edition, Khanna publishers, 2005
7. Anna Mani, India. Dept. of Non-conventional Energy Sources, Wind energy resource survey in India , Allied Publishers, 1990
8. IEEE Journals for Power, Energy, & Industry Applications
9. IS 875 Part IV and IS 1893 semics D+STDS mareials STDS IS 226 (IS 2862, ASTMS 36, BS 4360 GR 43D and A).

MEN017 ELECTRICAL DRIVES AND CONTROLS L T P C
3 0 0 3

UNIT I CONVENTIONAL MOTOR DRIVES 9

Characteristics of DC and AC motor 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 SOLID STATE POWER CONTROLLERS 9

Power devices - Triggering Circuits – Rectifiers – Choppers - Inverters – 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

Single and Three Phase fed DC motor drives - AC motor drives - Voltage Control - Rotor resistance control - Frequency control - Slip Power Recovery scheme.

TOTAL: 45PERIODS

REFERENCES:

1. U.A.Bakshi, M.V.Bakshi, Electrical Drives and Control, Technical Publications, 2009.
2. Singh, K B Khanchandani, Singh ;Power Electronics Tata McGraw-Hill Education, 2008
3. Pillai.S.K, A First course on Electrical Drives,2nd Edition, New Age International, 2007
4. Tai L. Chow ,Introduction to electromagnetic theory: a modern perspective, Jones & Bartlett Learning, 2006.
5. NKDE and P.K.Sen, Electrical drives, PHI Learning Pvt. Ltd., 2004.
6. P.S.Bimbhra, Power Electronics, Khanna Publishers, 2003.

MEN018 FLUIDIZED BED SYSTEMS L T P C
3 0 0 3

UNIT I FLUIDIZED BED BEHAVIOUR 12

Characterization of bed particles - comparison of different methods of gas – solid contacts.Fluidization phenomena - regimes of fluidization – bed pressure drop curve.Two phase and well-mixed theory of fluidization.Particle entrainment and elutriation – unique features of circulating fluidized beds.

UNIT II HEAT TRANSFER 6

Different modes of heat transfer in fluidized bed – bed to wall heat transfer – gas to solid heat transfer – radiant heat transfer – heat transfer to immersed surfaces.Methods for improvement – external heat exchangers – heat transfer and part load operations.

UNIT III COMBUSTION AND GASIFICATION 6

Fluidized bed combustion and gasification – stages of combustion of particles – performance - start-up methods. Pressurized fluidized beds.

UNIT IV DESIGN CONSIDERATIONS 9

Design of distributors – stoichiometric calculations – heat and mass balance – furnace design – design of heating surfaces – gas solid separators.

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:

1. Prabir Basu., Combustion and gasification in fluidized beds, CRC/Taylor & Francis, 2006
2. Simeon Oka, E. J. Anthony, Fluidized bed combustion, M. Dekker, 2004
3. Wen-ching Yang, Handbook of fluidization and fluid-particle systems, Marcel Dekker, 2003
4. C. K. Gupta, D. Sathiyamoorthy ,Fluid bed technology in materials processing, CRC Press, 1999
5. Otto Molerus, Karl-Ernst Wirth, Heat transfer in fluidized beds, Springer, 1997

MEN019 HYDRO POWER TECHNOLOGY L T P C
3 0 0 3

UNIT - I HYDROLOGY 9

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 PROTO TYPE SYSTEMS 12

Advances in Planning, Design and Construction of Hydroelectric Power Stations-Trends in Development of Generating Plant and Machinery-Plant Equipment for pumped Storage Schemes-Some aspects of Management and Operations-Updating and Refurbishing of Turbines-Case Studies

UNIT - III SELECTION AND ANALYSIS OF TURBINES 7

Measurement of pressure head, Velocity- Various parameters for finding out the potential of Hydro Energy- Selection of turbines based on Specific quantities- Case study.

UNIT - IV HYDRO POWER STATION OPERATION, MAINTENANCE AND TROUBLE SHOOTING 10

Governing of Power Turbines-Functions of Turbine Governor-Condition for Governor Stability-Surge Tank Oscillation and Speed Regulative Problem of Turbine Governing in Future Planning, Design and Construction of Hydroelectric Power Stations-Remaining Lifecycle Analysis.

UNIT - V SMALL, MINI AND MICRO HYDRO POWER PLANTS TURBINES 9

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:

1. P.K Nag ,Power plant Engineering, Tata McGraw-Hill Education, 2008
2. A.K.Raja, Amit Prakash Srivastava, Power Plant Engineering, New Age International, 2007
3. Finn R. Førsund , Hydropower economics, Springer, 2007
4. Scott Davis, Microhydro: clean power from water, New Society Publishers, 2004.

MEN020 NUCLEAR ENGINEERING L T P C
3 0 0 3

UNIT I NUCLEAR REACTIONS 9

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 9

Nuclear Fuel Cycles - characteristics of nuclear fuels - Uranium - production and purification of Uranium - conversion to UF4 and UF6 - other fuels like Zirconium, Thorium - Berylium.

UNIT III REPROCESSING 9

Nuclear fuel cycles - spent fuel characteristics - role of solvent extraction in reprocessing - solvent extraction equipment.

UNIT IV SEPARATION OF REACTOR PRODUCTS 9

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 9

Types of nuclear wastes - safety control and pollution control and abatement - international convention on safety aspects - radiation hazards prevention.

TOTAL: 45 PERIODS

REFERENCES:

1. Raymond LeRoy Murray, Nuclear energy: an introduction to the concepts, systems, and applications of nuclear processes,6th Edition, Butterworth-Heinemann, 2009
2. John R. Lamarsh, Introduction to nuclear reactor theory, American Nuclear Society, 2002
3. Glasstone, S. and Sesonske, A, Nuclear Reactor Engineering, 4th Edition, Springer, 1994.
4. Winterton, R.H.S., Thermal Design of Nuclear Reactors, Pergamon Press, 1981.

MEN021 ADVANCED HEAT TRANSFER L T P C
3 0 0 3

UNIT I CONDUCTION AND RADIATION HEAT TRANSFER 10

One dimensional energy equations and boundary condition - three-dimensional heat conduction equations - extended surface heat transfer - conduction with moving boundaries - radiation in gases and vapour. Gas radiation and radiation heat transfer in enclosures containing absorbing and emitting media – interaction of radiation with conduction and convection.

UNIT II TURBULENT FORCED CONVECTIVE HEAT TRANSFER 10

Momentum and energy equations - turbulent boundary layer heat transfer – mixing length concept - turbulence model – k Є model - analogy between heat and momentum transfer – Reynolds, Colburn, Prandtl turbulent flow in a tube - high speed flows.

UNIT III PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGER 8

Condensation with shears edge on bank of tubes - boiling – pool and flow boiling -heat exchanger -Є – NTU approach and design procedure - compact heat exchangers.

UNIT IV NUMERICAL METHODS IN HEAT TRANSFER 9

Finite difference formulation of steady and transient heat conduction problems – Discretization schemes – explicit - Crank Nicolson and fully implicit schemes - control volume formulation -steady one-dimensional convection and diffusion problems - calculation of the flow field – SIMPLER Algorithm.

UNIT V MASS TRANSFER AND ENGINE HEAT TRANSFER CORRELATION 8

Mass transfer - vaporization of droplets - combined heat and mass transfers – heat transfer correlations in various applications like I.C. engines - compressors and turbine

TOTAL: 45 PERIODS

REFERENCES:

1. Incropera F.P. and DeWitt. D.P., Fundamentals of Heat & Mass Transfer, 7th Edition John Wiley & Sons, 2011.
2. F Kreith, et,al. Principles of Heat Transfer,7th Edition, Cengage Learning, 2010.
3. M. M. Rathore, R. Kapuno., Engineering Heat Transfer,2nd Edition, Jones & Bartlett Learning, 2010
4. W. J. Minkowycz, E. M. Sparrow., Advances in Numerical Heat Transfer, Taylor and Francis, 2009
5. Holman.J.P, Heat Transfer, 10th Edition, McGraw Hill Higher Education, 2009.
6. Nag.P.K, Heat Transfer, Tata McGraw-Hill, 2006

MEN022 INSTURMENTATION AND CONTROL SYSTEMS FOR THERMAL SYSTEMS

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UNIT I MEASUREMENT CHARACTERISTICS 12

Instrument classification - characteristics of instruments – static and dynamic experimental error analysis - systematic and random errors - statistical analysis – uncertainty - experimental planning and selection of measuring instruments - reliability of instruments

UNIT II MICROPROCESSORS AND COMPUTERS IN MEASUREMENT 5

Data logging and acquisition use of sensors for error reduction elements of micro – computer interfacing - intelligent instruments in use.

UNIT III MEASUREMENT OF PHYSICAL QUANTITIES 10

Measurement of thermo – physical properties, instruments for measuring temperature - pressure and flow - use of sensors for physical variables

UNIT IV ADVANCE MEASUREMENT TECHNIQUES 8

Shadow graph – Schileren – interferometer - Laser doppler anemometer - hot wire anemometer, heat flux sensors - telemetry in measurement.

UNIT V CONTROL SYSTEMS 10

Adaptive Control: Introduction, controllability, observability, Time optimal control system, Adaptive control. Digital Control: Introduction, Microprocessor PC based control applications, PID controllers.

TOTAL: 45 PERIODS

REFERENCES:

1. Manabendra Bhuyan, Intelligent Instrumentation, CRC Press, 2009
2. Morris A.S., Principles of Measurements and Instrumentation, Butterworth-Heinemann, 2003
3. Ernest Doebelin, Measurement Systems, McGraw-Hill, 2003
4. Holman, J.P. Experimental methods for engineers, 7th Edition, McGraw – Hill, 2001
5. Rangan., Instrumentation Devices and Systems, Tata McGraw-Hill Education, 2001
6. John G. Webster., The measurement, instrumentation, and sensors handbook, Springer, 1999

MEN023 SOLAR REFRIGERATION AND AIRCONDITIONING L T P C
3 0 0 3

UNIT I **9**

Potential and scope of solar cooling. Types of solar cooling systems, solar collectors and storage systems for solar refrigeration and airconditioning.

UNIT II **9**

Solar operation of vapour absorption and compression refrigeration cycles and their assessment.

UNIT III **9**

Thermal modelling and computer simulation for continuous and intermittent solar refrigeration and airconditioning systems.

UNIT IV **9**

Solar dessicant cooling systems. Open cycle absorption/ desorption solar cooling alternatives. Advanced solar cooling systems. Refrigerant storage for solar absorption cooling systems.

UNIT V **9**

Solar thermoelectric refrigeration and airconditioning. Solar economics of cooling systems.

TOTAL: 45 PERIODS

REFERENCES:

1. Ursula Eicker, Low Energy Cooling for Sustainable Buildings, John Wiley and Sons, 2009
2. Hans-Martin Henning, Solar-assisted air conditioning in buildings: a handbook for planners , Springer, 2007
3. M. Santamouris, D. Asimakopoulos, Passive cooling of buildings, Earthscan, 1996
4. A. A. M. Sayigh, J. C. McVeigh, Solar air conditioning and refrigeration, Pergamon Press, 1992
5. IEEE Journals for Power, Energy, & Industry Applications

MEN024 COMPUTATIONAL FLUID DYNAMICS L T P C
3 0 0 3

UNIT I **9**

Governing Equations of Fluid Flow, Finite Difference, Finite Volume, Finite Element Methods, Laplace Equation, Diffusion Equation or Wave Equation

UNIT II **9**

Application of Finite Volume Method to Fluid Flow problems - Pressure CorrectionTechniques-Gauss Siedel, Gauss Jordan. Introduction to Multi grid Methods. Boundary Conditions

UNIT III **9**

Structured and Unstructured Mesh- Introduction to CAD systems and Different Standards used for DATA Exchange.

UNIT IV **9**

Governing Equations for Turbulent Flow, Rotating Machinery, Combusting Flow and Multiphase Flow.

UNIT V **9**

Simple Internal Flows: T-Junction, Driven Cavity, Manifold, Valves, External Flows: Flow Over Ahmed Body, Car-Reacting Flow in a Gas Burner, Multiphase Flow in an Air Lift Reactor.

TOTAL: 45 PERIODS

REFERENCES

1. G. Ramamurty, Applied Finite Element Analysis, I. K. International Pvt Ltd, 2010
2. T. J. Chung, Computational fluid dynamics, Cambridge University Press, 2010
3. Niyogi , Introduction to Computational Fluid Dynamics, Pearson Education India, 2006
4. J. Blazek, Computational fluid dynamics: principles and applications, Elsevier, 2005

MEN025 FUEL CELLS AND HYDROGEN ENERGY L T P C
3 0 0 3

UNIT-I FUEL CELL BASICS 9

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 9

Classification by operating temperature/electrolyte type, Fuel Cell Performance, Activation, Ohmic and Concentration over potential

UNIT-III FUEL CELL DESIGN AND COMPONENTS 9

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 9

Production of hydrogen from fossil fuels, electrolysis, thermal decomposition, photochemical and photo-catalytic methods.

UNIT-V HYDROGEN STORAGE METHODS 9

Metal hydrides, metallic alloy hydrides, carbon nano-tubes, sea as source of deuterium.

TOTAL: 45 PERIODS

REFERENCES

1. A Faghri and Y Zhang, Transport Phenomena in Multiphase Systems, Elsevier 2006
2. S Srinivasan, Fuel Cells: From Fundamentals to Applications, Springer 2006
3. O'Hayre, SW Cha, W Colella and FB Prinz, Fuel Cell Fundamentals, Wiley, 2005
4. Xianguo Li, Principles of Fuel Cells, Taylor and Francis, 2005
5. J Larminie and A Dicks, Fuel Cell Systems Explained, 2nd Edition, Wiley,2003
6. IEEE Journals for Power, Energy, & Industry Applications.