KALASALINGAM UNIVERSITY

Anand Nagar, Krishnankoil - 626 190
Srivilliputhur Taluk, Virudhunagar District, Tamil Nadu, India

CURRICULUM AND SYLLABUS

2007-2008

M. TECH
(ENERGY ENGINEERING)

Courses Offered by

CENTRE FOR AUTOMOTIVE SYSTEMS AND INDUSTRIAL ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING
KALASALINGAM UNIVERSITY

&

RWTH, AACHEN UNIVERSITY OF TECHNOLOGY
GERMANY

KALASALINGAM UNIVERSITY

DEPARTMENT OF MECHANICAL ENGINEERING

M.Tech (ENERGY ENGINEERING)

SEMESTER - I

Code No	Course Title	L	T	P	C
THEORY					
MAT5109	Applied Mathematics	3	0	0	3
MEC5101	Advanced Heat Transfer	3	0	0	3
MEC5102	Advanced Thermodynamics	3	0	0	3
MEC5103	Advanced Fluid Mechanics	3	0	0	3
MEC5104	Fuels and Combustion	3	0	0	3
MECxxx	Elective I	3	0	0	3
PRACTICAL					
MEC5181	Energy Laboratory	0	0	3	2
	Total	15	0	3	20

SEMESTER - II

Code No	Course Title	L	T	P	C
THEORY					
MEC5105	Energy Conservation and Management	3	0	0	3
MEC5106	Environmental Pollution Control	3	0	0	3
MEC5107	Instrumentation for Thermal Systems	3	0	0	3
MEC5108	Renewable Energy Systems	3	0	0	3
MEC5109	Energy Systems Modeling and Analysis	3	0	0	3
MECxxx	Elective II	3	0	0	3
PRACTICAL					
MEC5182	Simulation Laboratory	0	0	3	2
	Total	15	0	3	20

SEMESTER - III

Code No	Course Title	L	T	P	M
THEORY					
MECxxx	Elective III	3	0	0	3
MECxxx	Elective IV	3	0	0	3
MECxxx	Elective V	3	0	0	3
PRACTICAL					
MEC6198	Project Work – Phase I	0	0	18	6
	Total	9	0	18	15

SEMESTER - IV

Code No	Course Title	L	T	P	C
PRACTICAL					
MEC6199	Project Work – Phase II	0	0	36	12

Total Credits = 67

LIST OF ELECTIVES

M.Tech (ENERGY ENGINEERING)

Code No	Course Title	L	T	P	C
MEC5111	Cogeneration and Waste Heat Recovery Systems	3	0	0	3
MEC5112	Boiler Technology	3	0	0	3
MEC5113	Fluidized Bed Systems	3	0	0	3
MEC5114	Design of Heat Exchanger	3	0	0	3
MEC5115	Thermal Storage Systems	3	0	0	3
MEC5019	Computational Fluid Dynamics	3	0	0	3
MEC6101	Energy Conversion Techniques	3	0	0	3
MEC6102	Power Generation, Transmission and Utilization	3	0	0	3
MEC6103	Waste Management and Energy Recovery	3	0	0	3
MEC6104	Clean Development Mechanism	3	0	0	3
MEC6105	Solar Energy Systems	3	0	0	3
MEC6106	Bio Energy Conversion Techniques	3	0	0	3
MEC6107	Nuclear Engineering	3	0	0	3
MEC6108	Wind Energy and Other Systems	3	0	0	3
MEC5002	Finite Element Analysis	3	0	0	3

SEMESTER I

MAT5009	APPLIED MATHEMATICS	L	T	P	C
		3	0	0	3

[(Common for M.Tech (CAD/CAM), M.Tech (Energy) and M.Tech (ASE)]

ONE-DIMENSIONAL WAVE EQUATION
Laplace transform methods for one dimensional wave equation - displacements in a string - longitudinal vibration of an elastic bar - Fourier transformation methods for one - dimensional heat conduction problems in infinite and semi-infinite rod.

LAPLACE EQUATION
Laplace equation - properties of harmonic functions - Fourier transformation methods for Laplace equation - solutions for Poisson equation by Fourier transform method.

VARIATION AND ITS DERIVATIVES
Variation and its properties - Euler's equation - Functional dependent on first and higher order derivatives - Functionals dependent on functions of several independent variables - Some applications - Direct methods - Ritz and Kantorovich methods.

SOLUTION OF LAPLACE EQUATION
Solution of Laplace and Poisson equation on a rectangular region by Liebmann's method - Diffusion equation by the explicit and Crank Nicolson - implicit methods - stability and Convergence criterion - Solution of wave equation by explicit scheme.

SCHWARZ - CHRISTOFFEL TRANSFORMATION
The Schwarz - Christoffel transformation - Transformation of boundaries in parametric form - Physical applications - Application to fluid flow - Application to heat flow.

Text Book

1. Sneddon, I. N., Elements of partial differential equations, McGraw-Hill, 1986.

References

1. Spiegel, M. R., Theory and problems of complex variables with an introduction to confomal mapping and its applications, Schaum's outline series, McGraw-Hill Book Co., 1987.
2. Sankara Rao, k., Introduction to partial differential equations, Prentice-Hall of India, New Delhi, 1995.
3. Elsgolts, L., Differential equation and calculus of variations, Mir Publishers, Moscow, 1966.

MEC5101	ADVANCED HEAT TRANSFER	L	T	P	C
		3	0	0	3

CONDUCTION AND RADIATION HEAT TRANSFER

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.

TURBULENT FORCED CONVECTIVE HEAT TRANSFER

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.

PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGER

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

NUMERICAL METHODS IN HEAT TRANSFER

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

MASS TRANSFER AND ENGINE HEAT TRANSFER CORRELATION

Mass transfer, vaporization of droplets, combined heat and mass transfer, heat transfer correlations in various applications like I.C. Engines, compressors and turbines.

Text Book

1. Incropera, F. P. and DeWitt, D.P., Fundamentals of Heat and Mass Transfer, John Wiley and Sons, 1996.

References

1. Ozisik, M. N., Heat Transfer – Basic Approach, McGraw-Hill Co., 1985.
2. Schlichting, Gersten, Boundarylayer Theory, Springer, 2000.
3. P.K. Nag, Heat Transfer, Tata McGraw-Hill, 2002.
4. Rohsenow, W. M., Harnett, J. P, and Ganic, E. N., Handbook of Heat Transfer Applications, McGraw-Hill, NY1985.
5. Ghoshdasdidar, P. S., Compiler simulation of flow and Heat Transfer, Tata McGraw-Hill, 1998.
6. Patankar, S. V., Numerical heat Transfer and Fluid flow, Hemisphere Publishing Corporation,1980.

MEC5102	ADVANCED THERMODYNAMICS	L	T	P	C
		3	0	0	3

AVAILABILITY ANALYSIS AND THERMODYNAMIC PROPERTY RELATIONS
Availability, irreversibility and second-law efficiency for a closed system and steady - state control volume - availability analysis of simple cycles - thermodynamic potentials, Maxwell relations, generalized relation for changes in entropy, internal energy and enthalpy, generalized relations for Cp and Cv Clausius Claypeyron equation, Joule - Thomson Coefficient, Bridgman tables for thermodynamic relations.

REAL GAS BEHAVIOUR AND MULTI-COMPONENT SYSTEMS
Different equations of state, fugacity, compressibility, principle of corresponding states, use of generalized charts for enthalpy and entropy departure, fugacity coefficient, Lee-Kesler generalized three parameter tables - fundamental property relations for systems of variable composition, partial molar prosperities, real gas mixtures, ideal solution of real gases and liquids, equilibrium in multi phase systems, Gibbs phase rule for non-reactive components.

CHEMICAL THERMODYNAMICS AND EQUILIBRIUM
Thermo chemistry, first law analysis of reacting systems, adiabatic flame temperature, entropy change of reacting systems, second law analysis of reacting systems, criterion for reaction equilibrium composition.

STATISTICAL THERMODYNAMICS
Microstates and macrostates, thermodynamic probability, degeneracy of energy levels, Maxwell-Boltzman, Fermi-Dirac and Bose-Einstein statistics, microscopic interpretation of heat and work, evaluation of entropy, partition function, calculation of the microscopic properties from partition functions.

IRREVERSIBLE THERMODYNAMICS
Conjugate fluxes and forces, entropy production, Onsager's reciprocity relations, thermo-electric phenomena and formulations.

Text Book:

1. Kenneth Wark, Jr., Advanced Thermodynamics for Engineers, McGraw-Hill Inc., 1995.

References:

1. Bejan, A., Advanced Engineering Thermodynamics, John Wiley and Sons, 1998.
2. Holman, J. P., Thermodynamics, Fourth Ediction, McGraw-Hill Inc., 1998.
3. Smith, J. M and Van Ness., H.C., Introduction to chemical Engineering Thermodynamics, Fourth Edition, McGraw-Hill Inc., 1987.
4. Sonntag, R. E., and Vann Wylen, G, Introduction to Thermodynamics, Classical and Statistical, third Edition, John Wiley and Sons, 1991.
5. DeHoft, R. T. Thermodynamics in Materials Science, McGraw-Hill Inc., 1993.
6. Rao, Y. V. C., Postulational and Statistical thermodynamics, Allied Publisher Limited, New Delhi, 1994.

MEC5103	ADVANCED FLUID MECHANICS	L	T	P	C
		3	0	0	3

INTRODUCTION

Ideal and non-ideal flows, general equations of fluid motion, Navier - stokes equations and their exact solutions. Boundary layer theory, wedge flows, laminar flow over plates and through cylinders.

TWO DIMENSIONAL FLOWS

Subsonic flow, physical significance of irrotational motion – Kelvin's theorem – differential equation in terms of velocity potential and stream function – flow with small purtubaration – flow past a wave shaped wall – Gothert's rule – Prandtl Glanert rule – Hodograph method.

TURBULENT FLOW

Turbulence, models and flow equations - steady and unsteady turbulent boundary layers.

COMPRESSIBLE FLOW THROUGH DUCTS

Introduction to compressible viscous flow, governing equations, flow with friction flow with heat transfer, flow though nozzle and diffusers.

SHOCK WAVE

Normal and oblique shocks – Prandtl – Meyer expansion – Rankine – Hugnoit relation, Application of method of characteristics applied to two dimensional cases – simple supersonic wind tunnel, design of supersonic wind tunnel and nozzle.

Text Book:

1. T. Radhakrishnan, Gas Dynamics Prentice Hall, New Delhi, 1993.

References:

1. Mohanty, A. K, Fluid Mechanics, Prentice Hall of India, 1986.
2. Shapiro, A. F., The Dynamics of Compressible flow V d 1, The Ronald Press company, 1963.
3. Shames, Mechanics of Fluids, McGraw Hill Book company, 1962.
4. Schlichting, H., Boundary layer theory McGraw Hill Book Company, 1979.
5. S. M. Yahya, Fundamentals of Compressible Flow, New Age International Publishers, 1996.

MEC5104	FUELS AND COMBUSTION	L	T	P	C
		3	0	0	3

CHARACTERIZATION

Fuels - types and characteristics of fuels - determination of properties of fuels - fuels analysis - proximate and ultimate analysis - moisture determination - calorific value - gross and net calorific values - Calorimetry - DuLong's formula for CV estimation - flue gas analysis - Orsat apparatus - fuel and ash storage and handling – spontaneous ignition temperatures.

SOLID FUELS AND LIQUID FUELS

Types - coal family - properties - calorific value - ROM, DMMF, DAF and bone dry basis - ranking - bulk and apparent density - storage - washability - coking and caking coals - renewable solid fuels - biomass - wood waste - agro fuels - manufactured solid fuels - types - sources - petroleum fractions - classification - refining - properties of liquid fuels - calorific value, specific gravity, flash and fire point, octane number, cetane number etc, - alcohols - tar sand oil - liquification of solid fuels.

GASEOUS FUELS

Classification - composition and properties - estimation of calorific value - gas calorimeter. rich and lean gas - Wobble index - natural gas - dry and wet natural gas - stripped NG - foul and sweet NG - LPG - LNG - CNG - methane - producer gas - gasifiers - water gas - town gas - coal gasification - gasification efficiency - non-thermal route - biogas - digesters - reactions - viability - economics.

COMBUSTION: STOICHIOMETRY AND KINETICS

Stoichiometry - mass basis and volume basis, excess air calculation - fuel and flue gas compositions - calculations - rapid methods - combustion processes - stationary flame surface or flameless combustion - submerged combustion - pulsating and slow combustion explosive combustion - mechanism of combustion - ignition and ignition energy - spontaneous combustion - flame propagation - solid, liquid and gaseous fuels combustion - flame temperature - theoretical, adiabatic and actual - ignition limits - limits of inflammability.

COMBUSTION EQUIPMENTS

Coal burning equipments - types - pulverized coal firing - fluidized bed firing - fixed bed and recycled bed - cyclone firing - spreader stokers - vibrating grate stokers - sprinkler stokers, traveling grate stokers - oil burners - vaporizing burners, atomizing burners - design of burners - gas burners - atmospheric gas burners - air aspiration gas burners - burners classification according to flame structures - factors affecting burners and combustion.

Text Book:

1. Samir Sarkar, Fuels and Combustion, 2nd Edition, Orient Longman, 1990.

References:

1. Bhatt, Vora Stoichiometry, 2nd Edition, Tata Mcgraw Hill, 1984.
2. Blokh AG, Heat Transfer in Steam Boiler Furnace, Hemisphere Publishing Corpn, 1988.
3. Civil Davies, Calculations in Furnace Technology, Pergamon Press, Oxford, 1966.
4. Sharma SP, Mohan Chander, Fuels and Combustion, Tata Mcgraw Hill, 1984.

MEC5181	ENERGY LABORATORY	L	T	P	C
		0	0	3	2

Renewable Energy

- Performance testing of solar water heater.
- Characteristics of Solar photovoltaic devices.
- Testing of Gasifier.
- Study of biogas plant.
- Properties of fuel oils, biomass, biogas.
- Solar Radiation measurement.

Energy Conservation

- Boiler efficiency testing.
- Motor and pump efficiency testing.
- Energy consumption measurement of lighting systems.
- Variable Frequency Drive.
- Heat Exchangers.
- Refrigeration and Air conditioning systems.

Study of Advanced Energy Systems

- Fuel Cell.
- Geo Thermal Energy.
- Thermal Storage Systems.

SEMESTER II

MEC5105	ENERGY CONSERVATION AND MANAGEMENT	L	T	P	C
		3	0	0	3

INTRODUCTION

Energy scenario – India and world – energy resources availability in India – energy consumption – pattern, energy conservation potential – various industries and commercial establishments, energy intensive industry – an overview - energy conservation and energy efficiency – needs and advantages, energy auditing – types, methodologies, barriers, role of energy manager – energy audit questionnaire – energy conservation act.

THERMAL ENERGY AUDITING

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 systems – losses in boiler – methodology of upgrading boiler programme – energy conservation in refrigeration and air-conditioning systems.

ELECTRICAL ENERGY SYSTEMS

Captive power generation systems – biomass, wind and diesel power generation – KVA demand estimation – wheeling and banking concept – EB bill detailing. basics of monitoring and targeting – elements of monitoring and targeting, data and information analysis techniques – energy consumption, production, Cumulative sum of differences (CUSUM).

PERFORMANCE EVALUATION AND OPTIMIZATION OF ELECTRICAL UTILITIES

Principle – types – performance evaluation of transformers, energy distribution - cable selection and cable losses, capacitors, electric motors, electrical heating and lighting systems.

ENERGY MANAGEMENT

Importance of energy management, energy economics – discount rate, payback period, internal rate of return, life cycle costing risk and sensitivity analysis, financing, energy performance contract and role of ETCOS.

Text Book

1. Hamies, Energy Auditing and Conservation; Methods, Measurements, Management and Case Study, Hemisphere, Washington, 1980.

References

1. CB Smith, Energy Management Principles, Pergamon Press, New York, 1981.
2. Trivedi, P. R., and Jolka, K. R., Energy Management, Common Wealth Publication, New Delhi, 1997.
3. Handbook on Energy Efficiency, TERI, New Delhi, 2001.
4. Write, Larry C, Industrial Energy Management and Utilization, Hemisphere Publishers, Washington, 1998.

MEC5106	ENVIRONMENTAL POLLUTION CONTROL	L	T	P	C
		3	0	0	3

INTRODUCTION

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

AIR POLLUTION

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.

WATER POLLUTION

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

WASTE MANAGEMENT

Sources and classification – solid waste – hazardous waste - characteristics – collection and transportation - disposal – processing and energy recovery – waste minimization.

OTHER TYPES OF POLLUTION FROM INDUSTRIES

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

Text Book

1. G. Masters Introduction to Environmental Engineering and Science, Prentice Hall of India Pvt Ltd, New Delhi, 2003.

References

1. H. S. Peavy, D. R. Rowe, G. Tchobanoglous Environmental Engineering - McGraw- Hill Book Company, New York, 1985.
2. H.Ludwig, W.Evans, Manual of Environmental Technology in Developing Countries, International Book Company, Absecon Highlands, N.J., 1991.
3. Arcadio, P. Sincero and G. A. Sincero, Environmental Engineering – A Design Approach, Prentice Hall of India Pvt Ltd, New Delhi, 2002.

MEC5107	INSTRUMENTATION FOR THERMAL SYSTEMS	L	T	P	C
		3	0	0	3

MEASUREMENT CHARACTERISTICS
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.

MICROPROCESSORS AND COMPUTERS IN MEASUREMENT
Data logging and acquisition use of intelligent instrument for error reduction, elements of micro-computer interfacing, intelligent instruments in use.

MEASUREMENT OF PHYSICAL QUANTITIES
Measurement of thermo-physical properties, instruments for measuring temperature pressure and flow, use of intelligent instruments for the physical variables.

FLOW VISUALISATION
Techniques, shadow graph, Schileren, interferometer, Laser Doppler anemometer, heat flux measurement, Telemetry in engines.

MEASUREMENT ANALYSIS
Chemical, thermal, magnetic and optical gas analysers, measurement of smoke, dust and moisture, gas chromatography, spectrometry, measurement of pH, Review of basic measurement techniques.

Text Book

1. Holman, J. P., Experimental methods for engineers, McGraw-Hill, 1958.

References

1. Barney, Intelligent Instrumentation, Prentice Hall of India, 1988.
2. Prebrashensky. V., Measurement and Instrumentation in Heat Engineering, Vol.1 and 2 MIR Publishers, 1980.
3. Raman, C. S. Sharma, G.R., Mani, V.S.V., Instrumentation Devices and Systems, Tata McGraw-Hill, New Delhi, 1983.
4. Doeblin, Measurement System Application and Design, McGraw-Hill, 1978.
5. Morris, A. S, Principles of Measurements and Instrumentation Prentice Hall of India, 1998.

MEC5108	RENEWABLE ENERGY SYSTEMS	L	T	P	C
		3	0	0	3

INTRODUCTION
World energy use – reserves of energy resources – environmental aspects of energy utilisation – renewable energy scenario in India – potentials – achievements – applications.

SOLAR ENERGY
Solar thermal – flat plate and concentrating collectors – solar heating and cooling techniques – solar desalination – solar pond – solar cooker – solar thermal power plant solar photo voltaic conversion – solar cells – PV applications.

WIND ENERGY
Wind data and energy estimation – types of wind energy systems – performance – details of wind turbine generator – safety and environmental aspects.

BIOMASS ENERGY
Biomass direct combustion – biomass gasifier – biogas plant – ethanol production – bio diesel – cogeneration – biomass applications.

OTHER RENEWABLE ENERGY SOURCES
Tidal energy – wave energy – open and closed OTEC cycles – small hydro – geothermal energy – fuel cell systems.

Text Book

1. G.D. Rai, Non Conventional Energy Sources, Khanna Publishers, New Delhi, 1999.

References

1. S. P. Sukhatme, Solar Energy, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1997.
2. Godfrey Boyle, Renewable Energy, Power for a Sustainable Future, Oxford University Press, U.K, 1996.
3. Twidell, J. W. and Weir, A., Renewable Energy Sources, EFN Spon Ltd., UK, 1986.
4. G. N. Tiwari, Solar Energy – Fundamentals Design, Modelling and applications, Narosa Publishing House, New Delhi, 2002.
5. L. L. Freris, Wind Energy Conversion systems, Prentice Hall, UK, 1990.
6. Johnson Gary, L., Wind Energy Systems, Prentice Hall, New York, 1985.

MEC5109	ENERGY SYSTEMS MODELLING AND ANALYSIS	L	T	P	C
		3	0	0	3

INTRODUCTION

Primary energy analysis - dead states and energy components-energy balance for closed and control volume systems - applications of energy analysis for selected energy system design - modelling overview- levels and steps in model development - examples of models – curve fitting and regression analysis.

MODELLING AND SYSTEMS SIMULATION

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

OPTIMISATION

Objectives-constraints, problem formulation - unconstrained problems - necessary and sufficiency conditions - constrained optimisation- LaGrange multipliers, constrained variations, linear programming - simplex tableau, pivoting, sensitivity analysis.

ENERGY- ECONOMY MODELS

Multiplier analysis - energy and environmental Input / Output analysis - energy aggregation – econometric energy demand modelling - overview of econometric methods - dynamic programming - search techniques - Univariate / Multivariate.

APPLICATIONS AND CASE STUDIES

Case studies of optimisation in energy systems problems- dealing with uncertainty - probabilistic techniques - trade-offs between capital and energy using Pinch analysis.

Text Book:

1. W. F. Stoecker, Design of Thermal Systems, McGraw Hill, 1981.

References:

1. A. Bejan, G. Tsatsaronis and M. Moran, Thermal Design and Optimization, John Wiley and Sons, 1996.
2. S. S. Rao, Optimization theory and applications, Wiley Eastern, 1990.
3. S.S. Sastry, Introductory methods of numerical Analysis, Prentice Hall, 1988.
4. P. Meier, Energy Systems Analysis for Developing Countries, Springer Verlag, 1984.
5. R. de Neufville, Applied Systems Analysis, McGraw Hill, International Edition, 1990.
6. Beveridge and Schechter, Optimization Theory and Practice, McGraw Hill, 1970.

MEC5182	SIMULATION LABORATORY	L	T	P	C
		0	0	3	2

- Steady state conduction in solids.
- Steady state natural convection.
- Steady state radiation between black bodies.
- Combined conduction and convection (fluid - solid).
- Unsteady state conduction in solids.
- Unsteady state conduction and convection (fluid – solid).
- Steady state conduction in fluids.
- Steady state forced convection
- Steady state radiation between grey bodies.
- Combined conduction and convection in Fluids.
- Unsteady state conduction and convection in fluids.
- Solar radiation model.
- Energy system simulations.

LIST OF ELECTIVES

MEC5111	COGENERATION AND WASTE HEAT RECOVERY SYSTEMS	L	T	P	C
		3	0	0	3

INTRODUCTION

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

COGENERATION TECHNOLOGIES

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.

ISSUES AND APPLICATIONS OF COGENERATION TECHNOLOGIES

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

WASTE HEAT RECOVERY SYSTEMS

Selection 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, absorption systems.

ECONOMIC ANALYSIS

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.

Text Book

1. Charles H. Butler, Cogeneration, McGraw Hill Book Co., 1984.

References

1. EDUCOGEN – The European Educational tool for cogeneration, Second Edition, 2001.
2. Horlock, JH, Cogeneration - Heat and Power, Thermodynamics and Economics, Oxford, 1987.
3. Institute of Fuel, London, Waste Heat Recovery, Chapman and Hall Publishers, London, 1963.
4. Sengupta Subrata, Lee SS EDS, Waste Heat Utilization and Management, Hemisphere, Washington, 1983.
5. De Nevers, Noel., Air Polllution Control Engineering, McGrawHill, New York, 1995.

MEC5112	BOILER TECHNOLOGY	L	T	P	C
		3	0	0	3

INTRODUCTION
Boilers – classification – basic design steps – fuel stoichiometry calculations – enthalpy calculation of air and combustion products, heat balance.

DESIGN OF COAL PREPARATION SYSTEM
Pulverizing properties of coal – air system for pulverization, size reducing machines – design of coal preparation system for pulverised coal boilers – fuel feeding arrangements.

DESIGN OF BURNERS
Tangential fired burners – basics and design methods - oil burners – design of supply system – oil atomiser – air register – design principles.

DESIGN OF BOILER FURNACE
General design principles – flame emissivity, heat transfer calculation for pulverised coal boiler furnace, water wall arrangement, furnace emissivity, distribution of heat load in furnace.

DESIGN OF CONVECTIVE HEAT TRANSFER SURFACE
Design of economizer, superheater, reheater, air preheater - temperature control in superheater and reheater.

Text Book

1. Ganapathy, V. Industrial Boilers and Heat Recovery Steam Generators, Marcel Dekker Ink, 2003.

References

1. Prabir Basu, Cen Kefa et.al, Boilers and Burners – Design and Theory, Springer, 2000.
2. David Gunn, Robert Horton, Industrial Boilers, Longman Scientific and Technical Publication, 1986.
3. Carl Schields, Boilers – Type, Characteristics and Functions, McGraw Hill Publishers, 1982.

MEC5113	FLUIDIZED BED SYSTEMS	L	T	P	C
		3	0	0	3

FLUIDIZED BED BEHAVIOUR

Characterization of bed particles - fluidization phenomena, regimes of fluidization, bed pressure drop curve, two phase and well mixed theory of fluidization, solids mixing, particle entrainment and elutriation, features of circulating fluidized beds, comparison of different methods of gas-solid contacts.

HEAT TRANSFER

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

COMBUSTION AND GASIFICATION

Fluidized bed combustion and gasification, stages of combustion of particles, performance, start-up methods, pressurized fluidized bed systems, combustion in Circulating Fluidized Bed boilers.

DESIGN CONSIDERATIONS

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

INDUSTRIAL PROCESSES

Physical operations like transportation, mixing of fine powders, heat exchange, coating, drying and sizing, principles of synthesis reactions, cracking and reforming of hydrocarbons, carbonization and gasification, calcining and clinkering and gas solid reactions, sulphur retention and oxides of nitrogen emission control.

Text Book

1. Howard, J.R., Fluidized Bed Technology: Principles and Applications, Adam Hilger, New York, 1983.

References

1. Kunii, D. and Levespiel, O., Fluidization Engineering, John Wiley and Son Inc, New York, 1969.
2. Geldart, D., Gas Fluidization Technology, John Wiley and Sons, New York, 1986.
3. Howard, J. R. (Ed), Fluidized Beds: Combustion and Applications, Applied Science Publishers, New York, 1983.
4. Botteril, J. S. M., Fluid Bed Heat Transfer, Academic Press, London, 1975.
5. Basu, P. and Fraser, S. A., Circulating Fluidized Bed Boilers, Butterworth-Heinemann, Boston, 1991.
6. Yates, J. G., Fundamentals of Fluidized bed Chemical Processes, Butterworths, 1983.
7. Reed, T. B., Biomass Gasification: Principles and Technology, Noyes Data Corporation, New Jersey, 1981.

MEC5114	DESIGN OF HEAT EXCHANGER	L	T	P	C
		3	0	0	3

CONSTRUCTIONAL DETAILS AND HEAT TRANSFER
Types – shell and tube heat exchangers, regenerators and recuperators – industrial applications – temperature distribution and its implications – analysis of heat exchangers – LMTD and effectiveness method.

FLOW AND STRESS ANALYSIS
Effect of turbulence, friction factor, pressure loss, stress in tubes, header sheets and pressure vessels, thermal stresses, shear stresses, types of failures.

DESIGN ASPECTS
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.

COMPACT AND PLATE HEAT EXCHANGERS
Types – merits and demerits, design of compact heat exchangers, plate heat exchangers, performance influencing parameters, limitations.

CONDENSERS and COOLING TOWERS
Design of surface and evaporative condensers, cooling tower – performance characteristics.

Text Book:

1. Taborek, T., Hewitt, G. F., and Afgan, N., Heat Exchangers, Theory and Practice, McGraw-Hill Book Co., 1980.

References:

1. Walker, Industrial Heat Exchangers – A Basic Guide, McGraw Hill Book Co., 1980.
2. Nicholas Cheremistoff, Cooling Tower, Ann Arbor Science Pub., 1981.
3. Arthur, P. Frass, Heat Exchanger Design, John Wiley and Sons, 1988.

MEC5115	THERMAL STORAGE SYSTEMS	L	T	P	C
		3	0	0	3

INTRODUCTION
Necessity of thermal storage – energy storage devices – comparison of energy storage technologies, seasonal thermal energy storage.

SENSIBLE HEAT STORAGE SYSTEM
Basic concepts and modeling of heat storage units, modelling of simple water and rock bed storage system, pressurized water storage system, packed beds.

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

LATENT HEAT STORAGE SYSTEMS
Storage materials, modelling of phase change problems – temperature based model, enthalpy model, porous medium approach, conduction dominated phase change, convection dominated phase change.

APPLICATIONS
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.

Text Book

1. Schmidt, F. W., and Willmott, A. J., Thermal Storage and Regeneration, Hemisphere Publishing Corporation, 1981.

References

1. Lunardini, V. J., Heat Transfer in Cold Climates, D. Van Nostrand, Reinhold, N.Y 1981.
2. Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley and Sons Ltd, 2002.

MEC5019	COMPUTATIONAL FLUID DYNAMICS	L	T	P	C
		3	0	0	3

(Common for M.Tech (CAD/CAM) AND M.Tech (Energy Engineering)

GOVERNING DIFFERENTIAL EQUATION AND FINITE DIFFERENCE METHOD

Classification, initial and boundary conditions, initial and boundary value problems - finite difference method, central, forward, backward difference, uniform and non - uniform grids, numerical errors, grid independence test.

CONDUCTION HEAT TRANSFER

Steady one-dimensional conduction, two and three dimensional steady state problems, transient one-dimensional problem, two-dimensional transient problems.

INCOMPRESSIBLE FLUID FLOW

Governing equations, stream function – verticity method, determination of pressure for viscous flow, simple procedure of Patankar and Spalding, computation of boundary layer flow, Finite difference approach.

CONVECTION HEAT TRANSFER AND FEM

Steady one-dimensional and two-dimensional convection – diffusion, unsteady one-dimensional convection – diffusion, unsteady two -dimensional convection – diffusion - introduction to finite element method – solution of steady heat conduction by FEM – incompressible flow – simulation by FEM.

TURBULENCE MODELS

Algebraic models – one equation model, K - $\in$ models, standard and high and low Reynolds number models, prediction of fluid flow and heat transfer using standard codes.

Text Book:

1. Muralidhar, K., and Sundararajan, T., Computational Fluid Flow and Heat Transfer, Narosa Publishing House, New Delhi, 1995.

References:

1. Ghoshdasdidar, P. S., Computer Simulation of flow and heat transfer, Tata McGraw-Hill Publishing Company Ltd., 1998.
2. Subas, V. Patankar Numerical heat transfer fluid flow, Hemisphere Publishing Corporation,1980.
3. Taylor, C., and Hughes, J. B., Finite Element Programming of the Navier Stock Equation, Pineridge Press Limited, U.K., 1981.

4. Anderson, D. A., Tannehill, J. I., and Pletcher, R. H., Computational fluid Mechanics and Heat Transfer, Hemisphere Publishing Corporation, New York, USA, 1984.
5. Fletcher, C. A. J., Computational Techniques for Fluid Dynamics 1, Fundamental and General Techniques, Springer, Verlag, 1987.
6. Fletcher, C. A. J., Computational Techniques for Fluid Dynamics 2, Specific Techniques for Different Flow Categories, Springer, Verlag, 1987.
7. Bose, T. X., Numerical Fluid Dynamics, Narosa Publishing House, 1997.

MEC6101	ENERGY CONVERSION TECHNIQUES	L	T	P	C
		3	0	0	3

BASICS
Energy conservation – conventional techniques – reversible and irreversible cycles – Carnot, Stirling and Ericsson – Otto, Diesel, dual, Lenior, Atkinson, Brayton, Rankine.

DIRECT CONSERVATION OF THERMAL TO ELECTRICAL ENERGY
Thermoelectric converters – thermoelectric refrigerator – thermoelectric generator – thermionic converters – Ferro electric converter – Nernst effect generator – thermo magnetic converter.

CHEMICAL AND ELECTROMAGNETIC ENERGY TO ELECTRICAL ENERGY
Batteries – types – working – performance governing parameters – hydrogen energy – solar cells.

ENERGY STORAGE SYSTEMS
Introduction – storage of mechanical energy, electrical energy, chemical energy, thermal energy.

FUEL CELLS
Basics – working, advantages and drawbacks – types – comparative analysis – thermodynamics and kinetics of fuel cell process – performance of fuel cell – applications.

Text Book:

1. Archie. W. Culp, Principles of Energy Conversion, McGraw-Hill Inc., Singapore, 1991.

References:

1. K. Kordesch, G. Simader, Fuel Cell and Their Applications, Wiley-Vch, Germany 1996.
2. M. A. Kettari, Direct Energy Conservation, Addision – Wesley Pub. Co, 1997.
3. A. B. Hart and G. J. Womack, Fuel Cells: Theory and Application, Prentice Hall, Newyork Ltd., London, 1989.

MEC6102	POWER GENERATION, TRANSMISSION AND UTILIZATION	L	T	P	C
		3	0	0	3

CONVENTIONAL POWER GENERATION

Steam power plant-selection of site-generated layout, coal and ash handling-steam generating plants-feed make circuit, cooling towers, turbine governing - hydro power plant-selection of site, classification layout governing of turbines, nuclear power plants - selection of site, classification layout governing of turbines, nuclear fuels - nuclear reactors, nuclear disposal - gas turbine plants.

NON CONVENTIONAL POWER GENERATION

Wind power generation - characteristics of wind power, design of wind mills - tidal power generation-single and two basin systems - turbines for tidal power - solar power generation-energy from biomass, biogas and waste.

ECONOMICS OF POWER GENERATION

Daily load curves-load factor-diversity factor-load deviation curve-load management-number and size of generating unit, cost of electrical energy, tariff, power factor improvement.

ELECTRICAL POWER TRANSMISSION

Online diagram of transmission, sub transmission and distribution systems, comparison of systems(DC and AC)- EHVAC and HVDC transmission-layout of substations and bus bar arrangements - equivalents circuit of short, medium and large lines - transmission efficiency, regulation, reactive power, compensation, transmission, loss minimization.

UTILISATION OF ELECTRICAL ENERGY

Selection of electrical drives - Electrical characteristics and mechanical consideration s-size, rating and cost Transformer characteristics-illumination-laws of illumination, polar curve, incandascent, fluoroscent and vapour lamps-Design of OLTC lighting scheme of industry, electrical welding-energy efficient aspects of devices.

Text Book

1. C. L. Wadhwa, Generation Distribution and utilization of Electrical Energy, Wiley Eastern Ltd., India, 1989.

References

1. V. A. Venikov and B. V. Put Yatin, Introduction of Energy Technology, Electric power Engineering, MIR Publishers, Moscow, 1984.
2. M. L. Soni, P. V. Gupta and V. S. A. Bhatnagar, Course in Electrical Power, Dhanpat Rai and Sons, New Delhi, 1983.
3. J. W. Twidell and A. D. Weir, Renewable Energy Sources, ELBS Edition 1986.
4. A. J. Wood and B. F. Wallenberg, Power Generation, Operation and Control,2nd Edition, JohnWiley and Sons, New York, 1986,
5. E. Khan, Electrical Utility Planning and Regulation, American Council for a n Energy Efficient Economy, Washington D.C., 1988.

MEC6103	WASTE MANAGEMENT AND ENERGY RECOVERY	L	T	P	C
		3	0	0	3

SOLID WASTE – CHARACTERISTICS AND PERSPECTIVES
Definition - types – sources – generation and estimation - properties - physical, chemical and biological – regulation.

COLLECTION, TRANSPORTATION AND PROCESSING TECHNIQUES
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 and electro mechanical.

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

HAZARDOUS WASTE MANAGEMENT
Hazardous waste – definition - potential sources - waste sources by industry – impacts – waste control methods – transportation regulations - risk assessment - remediation technologies.

ULTIMATE DISPOSAL
Landfill – classification – site selection parameters – design aspects – Leachate control – environmental monitoring system for land fill gases.

Text Book:

1. Tchobanoglous, Theisen and Vigil, Integrated Solid Waste Management, 2d Ed. McGraw-Hill, New York, 1993.

References:

1. Howard S. Peavy et.al, Environmental Engineering, McGraw Hill International 2nd Edition, 1985.
2. LaGrega, M., et al., Hazardous Waste Management, McGraw-Hill, C. 1200 pp.,ed., 2001.
3. Stanley E. Manahan. Hazardous Waste Chemistry, Toxicology and Treatment, Lewis Publishers, Chelsea, Michigan, 1990.
4. Parker, Colin and Roberts, Energy from Waste – An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985.
5. Manoj Datta, Waste Disposal in Engineered Landfills, Narosa Publishing House, 1997.

MEC6104	CLEAN DEVELOPMENT MECHANISM	L	T	P	C
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CLIMATE SCIENCE
World energy scenario - observed and modelled changes in climate - role of aerosols - climate change scenarios - global warming – factors contributing – comparison of global warming potential of GHG – impacts.

KYOTO PROTOCOL FORMATION
Historical perspectives from the industrial revolution to the United Nations Framework - convention on climate change and the Kyoto protocol, the Intergovernmental Panel on Climate Change (IPCC).

KYOTO PROTOCOL
Article 1 through 28 - accounted GHGs in Kyoto protocol – source categorization of GHG emissions – reduction commitment of Annexe B countries – C D M, joint implementation and emissions trading.

CLEAN DEVELOPMENT MECHANISM AND BASELINE STUDY SCENARIO
CDM and its economic viability for renewable energy projects – advantages for developing countries – emission and efficiency scenario of different energy sources for power generation - Baseline study – methodology – boundary conditions – base line fixing – typical case studies.

RECENT ADVANCEMENTS
Certification program – emission trade – policy and implications.

Text Book

1. Somerville, Richard C. J., Understanding Environmental Change, and the Forgiving Air, Los Angeles, University of California Press, 1996.

References

1. John Houghton, Global Warming, The Complete Briefing, Cambridge University Press, Cambridge, UK, 1997.
2. T. L Roleff, S. Barbour and K. L. Swisher, Global Warming, Opposing Viewpoints, Greenhaven Press, San Diego, 1997.

MEC6105	SOLAR ENERGY SYSTEMS	L	T	P	C
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BASICS IN SOLAR ENERGY SYSTEMS

Different types of renewable energy sources – sun as a source of energy – solar radiation – extra terrestrial at earth's surface – horizontal, tilted surface – estimation of radiation – hourly, daily and monthly average – alternation of solar radiation by atmosphere – effect of orientation of receiving surface.

MEASUREMENT OF SOLAR RADIATION

Measurement of solar radiation – radiation characteristics of opaque materials – radiation transmission through covers and absorption of collectors.

FLAT PLATE COLLECTORS

Theory of flat plate collectors – liquid and air flat plate collectors – design, performance and testing – other types of flat plate collectors.

CONCENTRATING COLLECTORS

Theory of concentrating collectors – modes of tracking – cylindrical parabolic collector – compound parabolic collector – central receiver collector – fixed reflector and tracking absorber collector – design, performance and testing.

APPLICATIONS

Thermal energy storage – various methods and applications, solar ponds – thermal applications – thermal power conversion, solar cooling and heating – solar desalination – drying – solar pumping.

Text Book

1. J. A. Duffie and W. A. Beckmann, Solar Engineering of Thermal Processes, John Wiley, London, 1991.

References

1. Sukhatme, S. P., Solar Energy Principles of Thermal Collection and Storage, Tata McGraw Hill Publishing Co., 1996.
2. Kreith, F., and Kreider J. F., Principles of Solar Engineering, McGraw hill Book Co., 1978.
3. Garg, H.P., Treatise on Solar Energy, Volume 1, 2 and 3, John Wiley and Sons, 1982.
4. Seshadri et.al., Climatological and Solar Data for India, Sarita Prakashan, 1969.

MEC6106	BIO ENERGY CONVERSION TECHNIQUES	L	T	P	C
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BASICS IN BIOMASS STUDY
Biomass- types – advantages and drawbacks – Indian scenario – characteristics – carbon neutrality – conversion mechanisms – fuel assessment studies.

BIOMETHANATION
Microbial systems – phases in biogas production – parameters affecting gas production – effect of additives on biogas yield – possible feed stocks - biogas plants – types – design – constructional details and comparison – biogas appliances – burner, illumination and power generation – effect on engine performance.

COMBUSTION
Perfect, complete and incomplete – equivalence ratio – fixed bed, fluid bed – fuel and ash handling – steam cost comparison with conventional fuels - briquetting - types of briquetting – merits and demerits – feed requirements and preprocessing – advantages – drawbacks.

GASIFICATION
Types – comparison – application – performance evaluation – economics – dual fuel engines – 100 % gas engines – engine characteristics on gas mode – gas cooling and cleaning train.

PYROLYSIS AND CARBONISATION
Types – process governing parameters – thermo gravimetric analysis – differential thermal analysis – differential scanning calorimetry – typical yield rates.

Text Book

1. David Boyles, Bio Energy Technology Thermodynamics and costs, Ellis Hoknood, Chichester, 1984.

References

1. Khandelwal, KC, Mahdi, SS., Biogas Technology – A Practical Handbook, Tata McGraw-Hill, 1986.
2. R. C. Mahaeswari, Bio Energy for Rural Energisation, Concepts Publication, 1997.
3. Tom, B. Reed, Biomass Gasification – Principles and Technology, Noyce DataCorporation, 1981
4. Best Practises Manual for Biomass Briquetting, I R E D A, 1997.
5. S. Eriksson and M. Prior, The briquetting of Agricultural wastes for fuel, FAO Energy and Environment paper, 1990.

MEC6107	NUCLEAR ENGINEERING	L	T	P	C
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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.

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.

REPROCESSING

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

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 Slagging and Electro - Refining - Isotopes - principles of isotope separation.

WASTE DISPOSAL AND RADIATION PROTECTION

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

Text Book

1. S. Glasstone and A. Sesonske, Nuclear Reactor Engineering, 3rd Edition, Von Nostrand, 1981.

References

1. J. R. Lamarsh, Introduction to Nuclear Reactor Theroy, Wesley, 1966.
2. J. J. Duderstadt and L. J. Hamiition, Nuclear Reactor Analysis - John Wiley, 1976.
3. A. E. Walter and A. B. Reynolds Fast Breeder Reactor, Pergamon Press, 1981.
4. R. H. S. Winterton, Thermal Design of Nuclear Reactors, Pergamon Press, 1981.

MEC6108	WIND ENERGY AND OTHER SYSTEMS	L	T	P	C
		3	0	0	3

BASICS IN WIND ENERGY SYSTEMS

Structure - statistics - measurements and data presentation – wind turbine aerodynamics – momentum theories - basic aerodynamics – airfoils and their characteristics – HAWT - blade element theory – Prandtl's lifting line theory (Prescribed wake analysis) VAWT aerodynamics - wind turbine loads – aerodynamic loads in steady operation – wind turbulence –Yawed Operation and Tower Shadow.

WIND ENERGY CONVERSION SYSTEMS (WECS)

Siting- rotor selection - annual energy output - Horizontal Axis Wind Turbine (HAWT) - Vertical Axis Wind Turbine (VAWT) - rotor design considerations - number of blades- blade profile- 2/3 blades and teetering – coning - upwind / downwind - power regulation - Yaw System - tower- synchronous and asynchronous generators and loads - integration of wind energy converters to electrical networks - inverters - testing of WECS - WECS control system- requirements and strategies - miscellaneous topics- noise etc - other applications.

GEO – THERMAL ENERGY SOURCES

Introduction – estimates to geo thermal sources – hydro thermal resources – applications for thermal and electricity generation – prime movers – impulse and reaction turbines. small and medium scale hydro power- ocean energy- introduction – OTEC conversion – thermal electric power generation, energy utilization – heat exchangers – site selection – potential impacts.

TIDES AND WAVES ENERGY SOURCES

Introduction – principle of tidal power – power plants – applications - utilization of tidal energy - application - site requirements - storage systems - different methods and potential in India-wave energy – introduction - basic concepts - wave power devices - wave energy conversion devices.

HYDRO POWER RESOURCES

Introduction - hydro electric basic concepts - hydro power plant- potential applications - potential development hydro power stations - components of hydro electric scheme - environmental aspects- potential impacts of harnessing the different renewable energy resources.

Text Book

1. L. L. Freris, Wind Energy Conversion Systems, Prentice Hall, 1990.

References

1. D. A. Spera, Wind Turbine Technology: Fundamental concepts of Wind Turbine Engineering, ASME Press.
2. A. Duffie and W. A. Beckmann, Solar Engineering of Thermal Processes, John Wiley, 1980.
3. F. Kreith and J. F. Kreider, Principles of solar Engineering, McGraw-Hill, 1978.

MEC5002	FINITE ELEMENT ANALYSIS	L	T	P	C
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(Common for M.Tech (CAD/CAM) AND M.Tech (Energy Engineering)

INTRODUCTION TO FEA

Historical background, weighted residual methods - basic concept of FEM variational formulation of boundry value problems - Ritz method - finite element modelling - element equation - linear and quadratic shape functions - bar, beam, elements - application to heat transfer.

HEAT TRANSFER AND FLUIDMECHANICS

Basic boundary value problems in 2 dimensions - triangular, quadrilateral, higher order elements - poisons and laplaces equation - weak formulation - element matrices and vectors - application to solid mechanics, heat transfer, fluid mechanics.

ISO-PARAMETRIC ELEMENT

Natural co-ordinate systems - lagrangian interpolation polynomials - isoparametric, elements - formulation numerical integration – one dimensional - two dimensional triangular elements - rectangular elements - illustrative examples.

PLANE STRESS AND STRAIN

Introduction to theory of elasticity - plane stress - plane strain and axisymetric formulation - principle of virtual work - element matrices using energy approach.

STRUCTURAL DYNAMICS APPLICATIONS

Dynamic analysis - equation of motions - mass matrices - free vibration analysis - natural frequencies of longitudinal - transverse and torsional vibration introduction to transient field problem - non linear analysis -uses of softwares - H and P elements - special element formulation.

Text Book

1. Reddy, J. N., An Introduction to the Finite Element Method, McGraw Hill, International Edition,1993

References

1. Segerlind, L. J., Applied Finite Element Analysis, John Wiley, 1984.
2. Rao, S. S, Finite Element Method in Engineering, Pergamon Press, 1989.
3. Chandrupatla and Belagundu, Finite Element in Engineering, Prentice Hall of India Private Ltd, 1997.
4. Cook,Robert, Davis, et.al, Concept and Applications of Finite Element Analysis, Wiley, John and Sons,1999.
5. George, R, Buchaman, Schaum's Outline of Finite Element Analysis, McGraw Hill Company, 1994.