ANNA UNIVERSITY, CHENNAI

AFFILIATED INSTITUTIONS

R - 2009

CURRICULUM I SEMESTER (FULL TIME)

M.E. THERMAL ENGINEERING

SEMESTER I

Code No	Course Title	L	T	P	C
Theory					
MA9215	Applied Mathematics for Thermal Engineers	3	1	0	4
TE9211	Advanced Heat Transfer	3	1	0	4
TE9212	Advanced Thermodynamics	3	1	0	4
TE9213	Advanced Engineering Fluid Mechanics	3	0	0	3
TE9214	Fuels and combustion	3	0	0	3
E1	Elective I	3	0	0	3
Practical					
TE9215	Thermal Engineering Lab	0	0	3	1
	Total	**18**	**3**	**3**	**22**

LIST OF ELECTIVES FOR M.E THERMAL ENGINEERING

Code No	Course Title	L	T	P	C
TE9250	Renewable Energy Systems	3	0	0	3
TE9251	Advanced Internal Combustion Engineering	3	0	0	3
TE9252	Turbomachines	3	0	0	3
IC9262	Computational Fluid Dynamics	3	0	0	3
TE9254	Cryogenic Engineering	3	0	0	3
TE9255	Refrigeration Machinery and components	3	0	0	3
TE9256	Fans, Blowers and Compressors	3	0	0	3
TE9257	Food Processing, Preservation and Transport	3	0	0	3
TE9258	Nuclear Engineering	3	0	0	3
TE9259	Industrial Refrigeration Systems	3	0	0	3
TE9260	Refrigeration Systems Design	3	0	0	3
IC9253	Gas Turbine Power Plants	3	0	0	3
IC9254	Space Propulsion	3	0	0	3
TE9263	**Fluid Flow and Heat Transfer in Engines**	3	0	0	3
TE9264	Boundary Layer Theory and Turbulence	3	0	0	3
IC9268	Fuel Cell Technology	3	0	0	3
TE9266	Design of Thermal Systems	3	0	0	3
TE9268	**Combustion Engineering**	3	0	0	3
TE9269	Energy conservation in Thermal Systems	3	0	0	3
TE9270	**Advanced Power Plant Engineering**	3	0	0	3
TE9271	**Steam Generator Technology**	3	0	0	3
TE9272	**Fluidized Bed Systems**	3	0	0	3
EY9256	Design of Heat Exchangers	3	0	0	3
TE9274	Advanced Thermal Storage Technologies	3	0	0	3

MA 9215 APPLIED MATHEMATICS FOR THERMAL ENGINEERS **L T P C 3 1 0 4**

UNIT I APPLICATIONS OF FOURIER TRANSFORM 9

Fourier Transform methods – one-dimensional heat conduction problems in infinite and semi-infinite rod – Laplace Equation – Poisson Equation.

UNIT II CALCULUS OF VARIATIONS 9

Concept of variation and its properties – Euler's equation – Functionals dependant on first and higher order derivatives – Functionals dependant on functions of several independent variables – Variational problems with moving boundaries – Direct methods – Ritz and Kantorovich methods.

UNIT III CONFORMAL MAPPING AND APPLICATIONS 9

The Schwarz- Christoffel Transformation – Transformation Of Boundaries In Parametric Form – Physical Applications:Fluid Flow And Heat Flow Problems**.**

UNIT IV FINITE DIFFERENCE METHODS FOR PARABOLIC EQUATIONS 9

One dimensional parabolic equation – Explicit and Crank-Nicolson Schemes – Thomas Algorithm – Weighted average approximation – Dirichlet and Neumann conditions – Two dimensional parabolic equations – ADI method.

UNIT V FINITE DIFFERENCE METHODS FOR ELLIPTIC EQUATIONS 9

Solutions of Laplace and Poisson equations in a rectangular region – Finite difference in polar coordinates – Formulae for derivatives near a curved boundary while using a square mesh.

L +T: 45+15 = 60 PERIODS

TEXT BOOKS :

1. Mitchell A.R. and Griffith D.F., The Finite difference method in partial differential equations, John Wiley and sons, New York (1980).
2. Sankara Rao, K., Introduction to Partial Differential Equations, Prentice Hall of India Pvt. Ltd., New Delhi (1997).
3. Gupta, A.S., Calculus of Variations with Applications, Prentice Hall of India Pvt. Ltd., New Delhi (1997).

REFERENCES:

1. Spiegel, M.R., Theory and Problems of Complex Variables and its Application (Schaum's Outline Series), McGraw Hill Book Co., Singapore (1981).
2. Andrews, L.C. and Shivamoggi, B.K., Integral Transforms for Engineers, Prentice Hall of India Pvt. Ltd., New Delhi (2003).
3. Elsgolts, L., Differential Equations and the Calculus of Variations, MIR Publishers, Moscow (1973).
4. Mathews, J.H. and Howell, R.W., Complex Analysis for Mathematics and Engineering, Narosa Publishing House, New Delhi (1997).
5. Morton, K.W. and Mayers, D.F. Numerical solution of partial differential equations, Cambridge University press, Cambridge (2002).
6. Jain, M. K., Iyengar, S. R. K. and Jain, R. K. " Computational Methods for Partial Differential Equations", New Age International (P) Ltd., 2003.

TE 9211 ADVANCED HEAT TRANSFER L T P C
3 1 0 4

OBJECTIVES:

- To develop the ability to use the heat transfer concepts for various applications like finned systems, turbulence flows, high speed flows.
- To analyse the thermal analysis and sizing of heat exchangers and to learn the heat transfer coefficient for compact heat exchanges**.**
- To achieve an understanding of the basic concepts of phase change processes and mass transfer.

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 turbines.

TOTAL (L :45 + T:15): 60 PERIODS

TEXT BOOKS:

1 Incropera F.P. and DeWitt. D.P., Fundamentals of Heat & Mass Transfer, John Wiley & Sons, 2002.
2.Holman.J.P, Heat Transfer, Tata Mc Graw Hill, 2002.

REFERENCES:

1. Ozisik. M.N., Heat Transfer – A Basic Approach, McGraw-Hill Co., 1985
2. Nag.P.K, Heat Transfer, Tata McGraw-Hill, 2002
3. Ghoshdastidar. P.S., Heat Transfer, Oxford University Press, 2004
4. Yadav, R., Heat and Mass Transfer, Central Publishing House, 1995.

TE 9212 ADVANCED THERMODYNAMICS L T P C
3 0 0 3

UNIT I AVAILABILITY ANALYSIS AND THERMODYNAMIC PROPERTY RELATIONS 10

Reversible work - 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 relations for changes in entropy - internal energy and enthalpy - generalized relations for C_p and C_V Clausius Clayperon equation, Joule – Thomson coefficient.Bridgeman tables for thermodynamic relations.

UNIT II REAL GAS BEHAVIOUR AND MULTI – COMPONENT SYSTEMS 10

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 properties.Real gas mixtures - Ideal solution of real gases and liquid - activity - equilibrium in multi phase systems - Gibbs phase rule for non – reactive components.

UNIT III CHEMICAL THERMODYNAMICS AND EQUILIBRIUM 10

Thermochemistry - First law analysis of reacting systems - Adiabatic flame temperature - entropy change of reacting systems - Second law analysis of reacting systems - Criterion for reaction equilibrium.Equilibrium constant for gaseous mixtures - evaluation of equilibrium composition.

UNIT IV STATISTICAL THERMODYNAMICS 8

Microstates and Macrostates - thermodynamic probability - degeneracy of energy levels - Maxwell – Boltzman, Fermi – Diarc and Bose – Einstein statistics - microscopic interpretation of heat and work, evaluation of entropy, partion function, calculation of the Macroscopic properties from partition functions.

UNIT V IRREVERSIBLE THERMODYNAMICS 7

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

TOTAL (L :45 + T:15): 60 PERIODS

TEXT BOOKS :

1. Kenneth Wark Jt.m, Advanced Thermodynamics for Engineers, McGrew – Hill Inc., 1995.
2. Bejan, A., Advanced Engineering Thermodynamics, John Wiley and Cons, 1988.
3. Holman, J.P., Thermodynamics, Fourth Edition, McGraw – Hill Inc., 1988.

REFERENCES :

1. Smith, J.M. and Van Ness., H.C., Introduction to Chemical Engineering Thermodynamics, Fourth Edition, McGraw – Hill Inc., 1987.
2. Sonntag, R.E., and Van Wylen, G, Introduction to Thermodynamics, Classical and Statistical Themodynamics, Third Edition, John Wiley and Sons, 1991.
3. Sears, F.W. and Salinger G.I., Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Third Edition, Narosa Publishing House, New Delhi, 1993.
4. DeHotf, R.T., Thermodynamics in Materials Science, McGraw – Hill Inc., 1993.

Rao, Y.V.C., Postulational and Statistical Thermodynamics, Allied Publisher Limited, New Delhi, 1999.

TE 9213 ADVANCED ENGINEERING FLUID MECHANICS L T P C
3 0 0 3

AIM:

To introduce the advanced concepts of fluid mechanics and aerodynamics with the emphasis on practical applications.

OBJECTIVES:

- To understand the laws of fluid flow for ideal and viscous fluids.
- To represent the real solid shapes by suitable flow patterns and to analyze the same for aerodynamics performances.
- To understand the changes in properties in compressible flow and shock expansion.

UNIT I BASIC EQUATIONS OF FLOW 6

Three dimensional continuity equation - differential and integral forms – equations of motion momentum and energy and their engineering applications.

UNIT II POTENTIAL FLOW THEORY 12

Rotational and irrorational flows - circulation – vorticity - stream and potential functions for standard flows and combined flows – representation of solid bodies by flow patters.Pressure distribution over stationery and rotating cylinders in a uniform flow - magnus effect - Kutta – Zhukovsky theorem.Complex potential functions.Conformal transformation to analyze the flow over flat plate, cylinder, oval body and airfoils.Thin airfoil theory – generalized airfoil theory for cambered and flapped airfoils.

UNIT III VISCOUS FLOW THEORY 9

Laminar and turbulent Flow - laminar flow between parallel plates - Poiseuille's equation for flow through circular pipes.Turbulent flow - Darcy Weisbach equation for flow through circular pipe - friction factor - smooth and rough Pipes - Moody diagram – losses during flow through pipes.Pipes in series and parallel – transmission of power through pipes.

UNIT IV BOUNDARY LAYER CONCEPT 9

Boundary Layer - displacement and momentum thickness - laminar and turbulent boundary layers in flat plates - velocity distribution in turbulent flows in smooth and rough boundaries - laminar sub layer.

UNIT V COMPRESSIBLE FLUID FLOW 9

One dimensional compressible fluid flow – flow through variable area passage – nozzles and diffusers – fundamentals of supersonics – normal and oblique shock waves and calculation of flow and fluid properties over solid bodies (like flat plate, wedge, diamond) using gas tables

TOTAL: 45 PERIODS

TEXT BOOKS:

1.Houghten, E.L. and Carruthers, N.B., Aerodynamics for Engineering Students, Arnold Publishers, 1993.
2. Anderson, J.D., Fundamentals of Aerodynamics, McGraw Hill, Boston, 2001.

REFERENCES:

1.Streeter, V.L., Wylie, E.B., and Bedford, K.W., Fluid Mechanics, WCB McGraw Hill, Boston, 1998.
2.Munson, B.R., Young, D.F. and Okiisi, T.H., Fundamentals of Fluid Mechanics, John Wiley and Sons Inc., NewYork, 1990
3.Kumar, K.L., Engineering Fluid Mechanics, Eurasia Publishing House, New Delhi, 2002
4.Bansal, R.K., Fluid Mechanics, Saurabh and Co., New Delhi, 1985.

TE 9214 FUELS AND COMBUSTION L T P C
3 0 0 3

UNIT I CHARACTERIZATION 8

Fuels - Types and Characteristics of Fuels - Determination of Properties of Fuels - Fuels Analysis - Proximate and Ultimate Analysis - Moisture Determination - Calorific Value - Gross & Net Calorific Values - Calorimetry - DuLong's Formula for CV Estimation - Flue gas Analysis - Orsat Apparatus - Fuel & Ash Storage & Handling - Spontaneous Ignition Temperatures.

UNIT II SOLID FUELS & LIQUID FUELS 10

(a) Solid Fuels

Types - Coal Family - Properties - Calorific Value - ROM, DMMF, DAF and Bone Dry Basis - Ranking - Bulk & Apparent Density - Storage - Washability - Coking & Caking Coals - Renewable Solid Fuels - Biomass - Wood Waste - Agro Fuels - Manufactured Solid Fuels.

(b) Liquid Fuels

Types - Sources - Petroleum Fractions - Classification - Refining - Properties of Liquid Fuels - Calorific Value, Specific Gravity, Flash & Fire Point, Octane Number, Cetane Number etc, - Alcohols - Tar Sand Oil - Liquefaction of Solid Fuels.

UNIT III GASEOUS FUELS 7

Classification - Composition & Properties - Estimation of Calorific Value - Gas Calorimeter. Rich & Lean Gas - Wobbe Index - Natural Gas - Dry & Wet Natural Gas - Stripped NG - Foul & 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.

UNIT IV COMBUSTION : STOICHIOMETRY & KINETICS 12

Stoichiometry - Mass Basis & Volume Basis - Excess Air Calculation - Fuel & Flue Gas Compositions - Calculations - Rapid Methods - Combustion Processes - Stationary Flame - Surface or Flameless Combustion - Submerged Combustion - Pulsating & Slow Combustion Explosive Combustion.

Mechanism of Combustion - Ignition & Ignition Energy - Spontaneous Combustion - Flame Propagation - Solid, Liquid & Gaseous Fuels Combustion - Flame Temperature - Theoretical, Adiabatic & Actual - Ignition Limits - Limits of Inflammability.

UNIT V COMBUSTION EQUIPMENTS 8

Coal Burning Equipments - Types - Pulverized Coal Firing - Fluidized Bed Firing - Fixed Bed & 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 & Combustion.

TOTAL : 45 PERIODS

TEXT BOOKS :

1. Samir Sarkar, Fuels & Combustion, 2nd Edition, Orient Longman, 1990
2. Bhatt, Vora Stoichiometry, 2nd Edition, Tata Mcgraw Hill, 1984
3. Blokh AG,Heat Transfer in Steam Boiler Furnace, Hemisphere Publishing Corpn, 1988.

REFERENCES :

1. Civil Davies, Calculations in Furnace Technology, Pergamon Press, Oxford, 1966
2. Sharma SP, Mohan Chander, Fuels & Combustion, Tata Mcgraw Hill, 1984

TE 9215 THERMAL ENGINEERING LABORATORY L T P C
0 0 3 3

CYCLE 1

1. Performance test on Spark Ignition engines.
2. Emission measurement in Spark Ignition and Compression Ignition Engines.
3. Performance test on variable compression ratio petrol and diesel engines.
4. Performance study in a cooling tower
5. Performance study in a refrigeration and heat pump systems
6. Performance Study in a solar water heater

CYCLE 2

1. Properties of fuel oils, biomass, biogas
2. Solar Radiation measurement
3. Boiler efficiency testing
4. Performance of Heat Exchangers
5. Study on Fuel Cell Systems
6. Study on Thermal Storage Systems

TE 9250 RENEWABLE ENERGY SYSTEMS L T P C
3 0 0 3

UNIT I INTRODUCTION 7

World energy use – Reserves of energy resources – Environmental aspects of energy utilisation – Renewable energy scenario in India – Potentials – Achievements – Applications.

UNIT II SOLAR ENERGY 10

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.

UNIT III WIND ENERGY 8

Wind data and energy estimation – Types of wind energy systems – Performance – Details of wind turbine generator – Safety and Environmental Aspects.

UNIT IV BIOMASS ENERGY 8

Biomass direct combustion – Biomass gasifier – Biogas plant – Ethanol production – Bio diesel – Cogeneration – Biomass applications.

UNIT V OTHER RENEWABLE ENERGY SOURCES 12

Tidal energy – Wave energy – Open and closed OTEC Cycles – Small hydro – Geothermal energy – Fuel cell systems.

TOTAL : 45 PERIODS

TEXT BOOKS

1. G.D. Rai, Non Conventional Energy Sources, Khanna Publishers, New Delhi, 1999.
2. S.P. Sukhatme, Solar Energy, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1997.

REFERENCE BOOKS

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

TE 9251 ADVANCED INTERNAL COMBUSTION ENGINEERING L T P C
3 0 0 3

UNIT I SPARK IGNITION ENGINES 9

Spark ignition Engine mixture requirements – Fuel – Injection systems – Monopoint, Multipoint injection, Direct injection – Stages of combustion – Normal and abnormal combustion – factors affecting knock – Combustion chambers.

UNIT II COMPRESSION IGNITION ENGINES 9

States of combustion in C.I. Engine – Direct and indirect injection systems – Combustion chambers – Fuel spray behaviour – spray structure, spray penetration and evaporation – air motion – Introduction to Turbo charging.

UNIT III POLLUTANT FORMATION AND CONTROL 9

Pollutant – Sources – Formation of carbon monoxide, Unburnt hydrocarbon, NOx, Smoke and Particulate matter – Methods of controlling Emissions – Catalytic converters and Particulate Traps – Methods of measurements and Introduction to emission norms and Driving cycles.

UNIT IV ALTERNATIVE FUELS 9

Alcohol, Hydrogen, Natural Gas and Liquefied Petroleum Gas- Properties, Suitability, Merits and Demerits as fuels, Engine Modifications.

UNIT V RECENT TRENDS 9

Lean Burn Engines – Stratified charge Engines – homogeneous charge compression ignition engines – Plasma Ignition – Measurement techniques – laser Doppler, Anemometry.

TOTAL NO. OF : 45 PERIODS

TEXT BOOK

1. K.K. Ramalingam, Internal Combustion Engine Fundamentals, Scitech Publications, 2002.

REFERENCE BOOKS

1. R.B.Mathur and R.P. Sharma, Internal combustion Engines.
2. V. Ganesan, Int. Combustion Engines, II Edition, TMH, 2002.
3. Duffy Smith, auto fuel Systems, The Good Heart Willox Company, Inc., 198

TE 9252 **TURBOMACHINES** **L T P C**
3 0 0 3

AIM:

To instil the working principles, performance and applications of Turbomachines in the minds of the students.

OBJECTIVES:

- To introduce the energy transfer process in Turbomachines and governing equations of various forms.
- To understand the structural and functional aspects of major components of Turbomachines.
- To understand the applications of Turbomachines to gas turbine power plants and aerospace propulsion.

UNIT I INTRODUCTION 12

Basics of isentropic flow – diffuser and nozzle configurations - static and stagnation properties – area ratio – mass flow rate – critical properties - operating characteristics of diffuser and Nozzle. Various types of subsonic and supersonic inlets.Basics of Fanno and Rayleigh flow.Basics of normal and oblique shock waves.Use of gas tables.Energy transfer between fluid and rotor velocity triangles for a generalized turbomachine - methods of representing velocity diagrams - Euler turbine equation and its different forms - degree of reaction in turbo-machines – various efficiencies – isentropic, mechanical, thermal, polytropic etc.

UNIT II CENTRIFUGAL AND AXIAL FLOW COMPRESSORS 9

Centrifugal compressor - configuration and working – slip factor - work input factor – ideal and actual work - pressure coefficient - pressure ratio.Axial flow compressor – geometry and working – velocity diagrams – ideal and actual work – stage pressure ratio - free vortex theory – performance curves.

UNIT III COMBUSTION CHAMBER 6

Basics of combustion and chamber – chamber arrangements - flame stability – fuel injection nozzles. Swirl for stability - cooling of combustion chamber.

UNIT IV AXIAL AND RADIAL FLOW TURBINES 9

Elementary theory of axial flow turbines - stage parameters- multi-staging - stage loading and flow coefficients - degree of reaction - stage temperature and pressure ratios – single and twin spool arrangements – performance.Matching of components. Blade Cooling.Radial flow turbines.

UNIT V GAS TURBINE AND JET ENGINE CYCLES 9

Gas turbine cycle analysis – simple and actual – Reheater, Regenerator and Intercooled cycles.Working principles of Turbojet, Turbofan, Turboprop, Ramjet, Scarmjet and Pulsejet Engines and cycle analysis – thrust, specific impulse, sfc, thermal and propulsive efficiencies.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Khajuria P.R and Dubey S.P., Gas Turbines and Propulsive Systems, Dhanpat Rai Publications, 2003.
2. Ganesan, V. Gas Turbines, Tata McGrawHill, 1999.

REFERENCES:

1. Cohen, H., Rogers, G F C and Saravanmotto, H I H, Gas Turbine Theory, John Wiely, 5th Edition 2001.
2. Hill P G and Peterson C R, Mechanics and Thermodynamics of Propulsion, Addition- Wesley, 1970.
3. Mattingly J D, Elements of Gas turbine Propulsion, McGraw Hill, 1st Edition. 1997.

IC 9262 COMPUTATIONAL FLUID DYNAMICS L T P C
3 0 0 3

UNIT I GOVERNING DIFFERENTIAL EQUATION AND FINITE DIFFERENCE METHOD 10

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.

UNIT II CONDUCTION HEAT TRANSFER 10

Steady one-dimensional conduction, Two and Three dimensional steady state problems, Transient one-dimensional problem, Two-dimensional Transient Problems.

UNIT III INCOMPRESSIBLE FLUID FLOW 10

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.

UNIT IV CONVECTION HEAT TRANSFER AND FEM 10

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.

UNIT V TURBULENCE MODELS 5

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.

TOTAL : 45 PERIODS

REFERENCES

1. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 1995.
2. Ghoshdasdidar, P.S., "Computer Simulation of flow and heat transfer" Tata McGraw Hill Publishing Company Ltd., 1998.
3. Subas, V.Patankar "Numerical heat transfer fluid flow", Hemisphere Publishing Corporation, 1980.
4. Taylor, C and Hughes, J.B. "Finite Element Programming of the Navier Stock Equation", Pineridge Press Limited, U.K., 1981.

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

TE 9254 CRYOGENIC ENGINEERING L T P C
3 0 0 3

UNIT I INTRODUCTION 8

Insight on Cryogenics, Properties of Cryogenic fluids, Material properties at Cryogenic Temperatures. Applications of Cryogenics in Space Programs, Superconductivity, Cryo Metallurgy, Medical applications.

UNIT II LIQUEFACTION CYCLES 10

Carnot Liquefaction Cycle, F.O.M. and Yield of Liquefaction Cycles. Inversion Curve - Joule Thomson Effect. Linde Hampson Cycle, Precooled Linde Hampson Cycle, Claudes Cycle Dual Cycle, Ortho-Para hydrogen conversion, Eollins cycle, Simpson cycle, Critical Components in Liquefaction Systems.

UNIT III SEPARATION OF CRYOGENIC GASES 9

Binary Mixtures, T-C and H-C Diagrams, Principle of Rectification, Rectification Column Analysis - McCabe Thiele Method. Adsorption Systems for purification.

UNIT IV CRYOGENIC REFRIGERATORS 8

J.T.Cryocoolers, Stirling Cycle Refrigerators, G.M.Cryocoolers, Pulse Tube Refrigerators Regenerators used in Cryogenic Refrigerators, Dilution refrigerators, Magnetic Refrigerators

UNIT V HANDLING OF CRYOGENS 10

Cryogenic Dewar, Cryogenic Transfer Lines. Insulations used in Cryogenic Systems, Instrumentation to measure Flow, Level and Temperature.

TOTAL : 45 PERIODS

REFERENCES

1. Klaus D. Timmerhaus and Thomas M. Flynn, Cryogenic Process Engineering, Plenum Press, New York, 1989.
2. Randall F. Barron, Cryogenic Systems, McGraw-Hill, 1985.
3. Scott R.B., Cryogenic Engineering, Van Nostrand and Co., 1962.
4. Herald Weinstock, Cryogenic Technology, 1969.
5. Robert W. Vance, Cryogenic Technology, Johnwiley & Sons, Inc., New York, London.

WEB REFERENCES

1. www.nasa.gov
2. www.cryogenicsociety.org/
3. www.iifiir.org/

4. www.linde.com
5. www.airliquide.com/
6. www.cern.ch
7. www.nist.gov

TE 9255 REFRIGERATION MACHINERY AND COMPONENTS L T P C
3 0 0 3

UNIT I REFRIGERANT COMPRESSORS 9

Hermetic compressors - Reciprocating, Rotary, Scroll Compressors, Open type compressors - Reciprocating, Centrifugal, Screw Compressors. Semi hermetic compressors - Construction, working and Energy Efficiency aspects. Applications of each type.

UNIT II DESIGN OF CONDENSERS 10

Estimation of heat transfer coefficient, Fouling factor, Friction factor. Design procedures, Wilson plots, Designing different types of condensers, BIS Standards, Optimisation studies.

UNIT III DESIGN OF EVAPORATORS 10

Different types of evaporators, Design procedure, Selection procedure, Thermal Stress calculations, Matching of components, Design of evaporative condensers.

UNIT IV REFRIGERATION SYSTEM COMPONENTS 9

Evaporators and condensers - Different types, capacity control, circuitry, Oil return, Oil separators - Different types Refrigerant driers strainers, Receivers, Accumulators, Low pressure receivers, Air Washers, Spray ponds.

UNIT V SYSTEM ACCESSORIES AND CONTROLS 7

Refrigerant Pumps, Cooling Tower fans, Compressor Motor protection devices, Oil equalising in multiple evaporators. Different Defrosting and capacity control methods and their implications - Testing of Air conditioners, Refrigerators, Visicoolers, Cold rooms, Calorimetric tests.

TOTAL : 45 PERIODS

REFERENCES:

1) Chlumsky “Reciprocating & Rotary compressors”, SNTL Publishers for Technical literaure, 1965.
2) Hains, J.B, “ automatic Control of Heating & Airconditioning” Mc Graw Hill, 1981.
3) Althose, A.D. & Turnquist, C.H. “ Modern Refrigeration and Airconditioning” Good Heart - Wilcox Co. Inc., 1985.
4) Recent release of BIS Code for relevant testing practice.
5) ASHRAE Hand book : Equipments, 1998
6) Cooper &Williams, B. “ Commercial, Industrial, Institutional Refrigeration, Design, Installation and Trouble Shooting “ Eagle Wood Cliffs (NT) Prentice Hall, 1989.
7) http://www.chensources.com/ctowers22.shtml
8) http://www.fortunecity.com/campus/german/201/ctowers.html
9) http://www.aquasystemsinsc.com/metric-files.html
10) http://www.ori.org
11) http://confex.com/store/ashrae/index-features.html

TE 9256 **FANS, BLOWERS & COMPRESSORS** **L T P C**
3 0 0 3

UNIT I PRINCIPLES OF TURBO MACHINERY 10

Introduction to turbo machines - Transfer of energy to fluids - Performance characteristics - fan laws - Dimensionless parameters - Specific speed - selection of centrifugal, axial, and mixed flow machines.

UNIT II ANALYSIS OF CENTRIFUGAL BLOWERS AND FANS 10

Centrifugal Blowers: Theoretical characteristic curves, Eulers characteristics and Eulers velocity triangles, losses and hydraulic efficiency, flow through impeller inlet volute, diffusers, leakage disc friction mechanical losses multivane impellers of impulse type, crossflow fans.

UNIT III ANALYSIS OF COMPRESSOR 14

Rotor design airfoil theory, vortex theory, cascade effects, degree of reaction, blade twist stage design, surge and stall, stator and casing, mixed flow impellers.

UNIT IV TESTING AND CONTROL OF FANS 5

Fan testing, noise control, materials and components blower regulation, speed control, throttling, control at discharge and inlet.

UNIT V APPLICATIONS OF BLOWERS 6

Applications of blowers, induced and forced draft fans for air conditioning plants, cooling towers, ventilation systems, booster systems.

TOTAL : 45 PERIODS

REFERENCES

1. S.M. Yahya, " Fundamentals of Compressible Flow ", New Age International (P)Limited, New Delhi, 1996
2. Stepanoff A.J., Turboblowers, John Wiley & Sons, 1970.
3. Brunoeck, Fans, Pergamon Press, 1973.
4. Austin H. Church, Centrifugal pumps and blowers, John Wiley and Sons, 1980.
5. Dixon, Fluid Mechanics, Thermodynamics of turbomachinery Pergamon Press, 1984.
6. Dixon, Worked examples in turbomachinery, Pergamon Press, 1984.

WEB REFERENCES

1. http://www.petropager.com
2. http://www.tamil.org
3. http://www.erichson.com
4. http://www.apgate.com

TE 9257	FOOD PROCESSING, PRESERVATION AND TRANSPORT	L T P C 3 0 0 3

UNIT I INTRODUCTION: **9**

Microbiology of Food Products, Mechanism of food spoilage critical microbial growth requirements, Design for control of micro organisms, The role of HACCP, Sanitation, Regulation and standards

UNIT II PROCESSING & PRESERVATION 12

Thermodynamic properties and Transfer properties, Water content, Initial freezing temperature, Ice fraction, Transpiration of fresh fruits & vegetables, Food processing techniques for Dairy products, Poultry, Meat, Fruits & Vegetables

UNIT III FREEZING & DRYING 12

Precooling, Freeze drying principles, Cold storage & freezers, Freezing drying limitations, Irradiation techniques, Cryofreezing, Numerical and analytical methods in estimating Freezing, Thawing times, Energy conservation in food industry.

UNIT IV COLD STORAGE DESIGN & INSTRUMENTATION 7

Initial building consideration, Building design, Specialized storage facility, Construction methods, Refrigeration systems, Insulation techniques, Control & instrumentation, Fire protection, Inspection & maintenance

UNIT V TRANSPORT 5

Refrigerated transportation, Refrigerated containers & trucks, Design features, Piping & Role of cryogenics in freezing & transport

TOTAL : 45 PERIODS

REFERENCES

1. Alan Rodes, Principles of Industrial Microbiology, Pregmon International Pub., 1989.
2. Ibraham Dincer, Heat Transfer in Food Cooling Applications, Tailor & Francis Pub., 1997.
3. Stanley E. Charm, Fundamentals of Food Engineering, III Ed. AVI Pub. Company Inc. 1989.
4. Clive V.I. Dellino, Cold and Chilled Storage Technology, Van Nostrand Reinhold Pub. New York, 1991.
5. Arora C.P., Refrigeration and Air conditioning II Ed. McGraw-Hill, Pub., 2000.
6. ASHRAE Handbook, Refrigeration, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. Atlanta, 1988.

TE 9258 **NUCLEAR ENGINEERING** **L T P C**
3 0 0 3

AIM:
To provide in-depth knowledge on Nuclear reaction materials reprocessing techniques and also to understand nuclear waste disposal techniques and radiation protection aspects.

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

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 - refinng - 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

TEXT BOOKS:

1. Glasstone, S. and Sesonske, A, Nuclear Reactor Engineering, 3rd Edition, Von Nostrand, 1984.
2. Duderstadt, J.J. and Hamilton, L.J., Nuclear Reactor Analysis, John Wiley, 1976.

REFERENCES:

1. Lamarsh, J.R., Introduction to Nuclear Reactor Theory, Wesley, 1996.
2. Walter, A.E. and Reynolds, A.B., Fast Breeder Reactor, Pergamon Press, 1981.
3. Winterton, R.H.S., Thermal Design of Nuclear Reactors, Pergamon Press, 1981.

TE 9259 INDUSTRIAL REFRIGERATION SYSTEMS L T P C
3 0 0 3

UNIT I INTRODUCTION 6

Introduction to industrial refrigeration - difference from conventional system - applications - industrial and comfort air - conditioning - conditions for high COP

UNIT II COMPRESSORS 10

Reciprocating and screw compressor: Multistage industrial applications, cylinder arrangement, cooling methods - oil injection and refrigeration injection, capacity regulations - Economizers.

UNIT III EVAPORATORS AND CONDENSERS 12

Types of Evaporators, Liquid circulation: Mechanical pumping and gas pumping - advantage and disadvantage of liquid re-circulation - circulation ratio - top feed and bottom feed refrigerant - Net Positive Suction Head (NPSH) - two pumping vessel system - suction risers – design - piping loses. Different Industrial Condensers arrangement, Evaporators-Types and arrangement, liquid circulation, type of feed, refrigerant piping design , functional aspects. Lubricating oil: types - physical properties, types of circulation and oil separator

UNIT IV VESSELS 8

Vessels in industrial refrigeration: High pressure receiver - flash tank - liquid and vapour separator - separation enhancers - low pressure receivers - surge drum - surge line accumulator - thermosyphon receiver - oil pots.

UNIT V ENERGY CONSERVATION 9

Energy conservation and design considerations - source of losses - energy efficient components - heat reclaim - thermal storage: ice builder and ice harvester. Insulation: critical thickness - insulation cost and energy cost - vapour barriers - construction methods of refrigerated spaces.

TOTAL : 45 PERIODS

REFERENCES:

1. Wilbert F.Stoecker, Industrial Refrigeration Hand Book, McGraw-Hill, 1998.
2. ASHRAE Hand Book: Fundamentals, 1997.
3. ASHRAE Hand Book: Refrigeration, 1998.
4. ASHRAE Hand Book: HVAC Systems and Equipment, 1996.
5. Transport properties of SUVA Refrigerants, Du-Pont Chemicals, 1993.

TE 9260 REFRIGERATION SYSTEMS DESIGN L T P C
3 0 0 3

AIM:
To teach the students about Refrigeration System Design concepts.

OBJECTIVE:
- Teaching cycle analysis pertaining to Refrigeration systems.
- Teaching performance of system components and their balancing in cycles.

UNIT I REFRIGERATION CYCLES - ANALYSIS 10
Development of Vapor Compression Refrigeration Cycle from Reverse Carnot Cycle-conditions for high COP-deviations from ideal vapor compression cycle , Multipressure Systems , Cascade Systems-Analysis .

UNIT II MAIN SYSTEM COMPONENTS 12
Compressor- Types , performance , Characteristics of Reciprocating Compressors , Capacity Control , Types of Evaporators & Condensers and their functional aspects , Expansion Devices and their Behavior with fluctuating load.

UNIT III REFRIGERANTS 11
Classification of Refrigerants , Refrigerant properties , Oil Compatibility , Environmental Impact-Montreal / Kyoto protocols-Eco Friendly Refrigerants.
Different Types of Refrigeration Tools , Evacuation and Charging Unit , Recovery and Recycling Unit , Vacuum Pumps.

UNIT IV SYSTEM BALANCING & CONTROLS 6
Estimation of Cooling Load , System Equilibrium and Cycling Controls , Electric Circuits in- Refrigerators , Window A/C , Types of motors , Relays.

UNIT V OTHER REFRIGERATION CYCLES 6
Vapor Absorption Systems-Aqua Ammonia & LiBr Systems, Steam Jet Refrigeration Thermo Electric Refrigeration, Air Refrigeration cycles.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Dossat R.J., Principles of refrigeration, John Wiley, S.I. Version (2001).
2. Stoecker W.F., Refrigeration and Air conditioning, McGraw-Hill Book Company, 1989.

REFERENCES:

1. Jordan and Priester , Refrigeration and Air conditioning 1985.
2. Goshnay W.B., Principles and Refrigeration, Cambridge, University Press, 1985.
3. Langley , Billy C., 'Solid state electronic controls for HVACR' pentice-Hall 1986.

IC 9253 **GAS TURBINE POWER PLANTS** **L T P C**
3 0 0 3

OBJECTIVE:
To learn the working principle, operations and analysis of gas turbine power plant cycle, components selection or matching.

UNIT I GAS TURBINE CYCLES 10
Gas turbine cycles – Air Standard Analysis, Different configurations – Re-heater, Intercooler, Heat Exchanger; Component behaviour.

UNIT II AXIAL FLOW COMPRESSORS 9
Momentum and energy transfer in rotors - Velocity triangles - Stage performance - Degree of reaction - Three-dimensional analysis - Cascade testing - Compressor characteristic curves – Howell's Correlation - Surging and stalling.

UNIT III AXIAL FLOW TURBINES 8
Stage velocity triangles - impulse and reaction turbines, losses and co-efficient - blade design principles - three-dimensional analysis - testing and performance characteristics – Compounding methods - blade cooling.

UNIT IV CENTRIFUGAL COMPRESSORS AND RADIAL TURBINES 10
Construction and working principle - velocity triangles - backward, forward and radially swept blades - losses and coefficients- performance characteristics.
Types of inward flow radial (IFR) turbine – velocity triangles – thermodynamics of the 90^0 IFR turbine – optimum design solution of 90^0 IFR turbines – stage losses – performance characteristics.

UNIT V COMBUSTORS 8
Different types – Annular, Can-annular types - Flow pattern - Cooling methods - Material requirement – Gas turbine pollution and its reduction.

TOTAL : 45 PERIODS

TEXT BOOKS :

1. Cohen, H., Rogers, G.E.C., and Saravanamuttoo, H.I.H., Gas Turbine Theory, Longman Group Ltd, 1989.
2. Gordon C, Dates, Aero-thermodynamics of Gas Turbine and Rocket Propulsion AIAA Education Series, NY 1984.
3. Kerrebrock, J.L., Aircraft engines and gas turbines, The MIT Press.

REFERENCES:

1. Yahya, S.M., Turbines, Compressors and Fans, Tata McGraw-Hill, 1983.
2. Earl Logan, Jr., Hand book of Turbomachinery, Marcel Dekker, Inc., USA, 1992 Dixon, S.L., Fluid Mechanics and Thermodynamics of Turbomachinery, Pergamon Press, 1978.
3. Ganesan, V., Gas Turbines, Tata McGraw-Hill Pub.Co.Ltd., New Delhi, 1999.

IC 9254 **SPACE PROPULSION** **L T P C**
3 0 0 3

OBJECTIVE:
To gain insight on the working principle of rocket engines, different feed systems, propellants and their properties and dynamics of rockets.

UNIT I GAS DYNAMICS 8
Wave motion – Compressible fluid flow through variable area devices – Stagnation state and properties – Normal shock and oblique shock waves – Rayleigh and Fanno Flow.

UNIT II THERMODYNAMICS OF AIRCRAFT ENGINES 9
Theory of Aircraft propulsion – Thrust – Various efficiencies – Different propulsion systems – Turboprop – Ram Jet – Turbojet, Turbojet with after burner, Turbo fan and Turbo shaft.

UNIT III PERFORMANCE CHARCTERISTICS OF AIRCRAFT ENGINES 9
Engine – Aircraft matching – Design of inlets and nozzles – Performance characteristics of Ramjet, Turbojet, Scramjet and Turbofan engines.

UNIT IV ROCKET PROPULSION 9

Theory of rocket propulsion – Rocket equations – Escape and Orbital velocity – Multi-staging of Rockets – Space missions – Performance characteristics – Losses and efficiencies.

UNIT V ROCKET THRUST CHAMBER 10
Combustion in solid and liquid propellant rockets – Classification of propellants and Propellant Injection systems – Non-equilibrium expansion and supersonic combustion – Propellant feed systems – Reaction Control Systems – Rocket heat transfer.

TOTAL : 45 PERIODS

TEXT BOOKS

1. Philip G. Hill and Carl R.Peterson, Mechanics and Thermodynamics of Propulsion, Second Edition, Addition – Wesley Publishing Company, New York, 1992.
2. Zucrow N.J. Principles of Jet Propulsion and Gas Turbines, John Wiley and Sons Inc, New York, 1970.
3. Zucrow N.J. Aircraft and Missile Propulsion, Vol. I and Vol. II, John Wiley and Sons Inc, New York, 1975.

TE 9263 FLUID FLOW AND HEAT TRANSFER IN ENGINES L T P C
3 0 0 3

OBJECTIVE:
To visualize fluid in an IC engine, aspects of heat transfer and cooling of components.

UNIT I INTRODUCTION 5
Basic Laws, Newtonian Fluids, Navier – Stokes Equations, Compressible and Incompressible Flows, Stream Functions and velocity Potential, Vorticity Dynamics.

UNIT II LOW AND HIGH REYNOLDS NUMBER FLOWS 9
Ideal flows and Boundary layers, Flows at Moderate Reynolds Numbers, Characteristics of High – Reynolds Number Flow, Ideal Flows in a plane, Axi-symmertric and Three dimensional Ideal Flows and Boundary Layers, Low Reynolds Numbers Flows.

UNIT III LUBRICATION, SURFACETENSION EFFECTS, MICROSCALE EFFECTS 9
Lubrication approximation, Surface Tension effects, Microscale effects.

UNIT IV COMPRESSIBLE FLOW 10
One dimensional compressible Gas flow, Isentropic Gas Relations, Compressible Flow in Nozzles, Area – velocity Relations, Converging – Diverging Nozzle, Effects of viscous friction and Heat Transfer – Introduction to Multi Dimensional flow.

UNIT V CONVECTIVE HEAT TRANSFER – MASS TRANSFER AND HEAT TRANSFER IN POROUS MEDIA 12
Convective Heat Transfer – Parallel Flow (Hagen – Poiseuille Flow), Couette Flow Sudden acceleration of a Flat Plate, Creeping flow, Mass transfer Diffusion and Convection, combined Heat and Mass Transfer, Heat transfer in Porous Media.

TOTAL : 45 PERIODS

TEXT BOOKS :

1. Ronald L. Panton, Incompressible flow, 3rd Edition, Wiley, 2005.
2. K. Muralikdhar and G. Biswas, Advanced Engineering Fluid Mechanics, Narosa Publishing House, 1999.
3. Frank M. White, Fluid Mechanics, 4th Edition McGraw Hill, 1999.

REFERENCES :

1. Frank M. White, Viscous Fluid Flow, 2nd Edition, McGraw Hill, 1991.
2. I.G. Currie, Fundamental Mechanics of fluids, 2nd Edition, McGraw Hill 1993.
3. F.P. Incropera and B. Lavine, Fundamentals of Heat and Mass Transfer, 6th Edition, Willey, 2006.
4. J. Welty, c. Wicks, Fundamentals of Momentum, Heat and Mass Transfer, 4th

TE 9264 BOUNDARY LAYER THEORY AND TURBULENCE L T P C
3 0 0 3

OBJECTIVE :

To understand the theory of turbulent flow and its modeling, structure types and a detailed insight about turbulence.

UNIT I FUNDAMENTALS OF BOUNDARY – LAYER THEORY 9

Boundary – Layer Concept, Laminar Boundary Layer on a Flat Plate at zero incidence, Turbulent Boundary Layer on a Flat plate at zero incidence, Fully Developed Turbulent Flow in a pipe, Boundary Layer on an airfoil, Boundary Layer separation.

UNIT II TURBULENT BOUNDARY LAYERS 9

Internal Flows – Couette flow – Two-Layer Structure of the velocity Field – Universal Law of the wall – Friction law – Fully developed Internal flows – Chennel Flow, Couettee – Poiseuille flows, Pipe Flow.

UNIT III TURBULENCE AND TURBULENCE MODELS 9

Nature of turbulence – Averaging Procedures – Characteristics of Turbulent Flows – Types of Turbulent Flows – Scales of Turbulence, Prandtl's Mixing length, Two-Equation Models, Low – Reynolds – Number Models, Large – Eddy Simulation.

UNIT IV STATISTICAL THEORY OF TURBULENCE 9

Ensemble Average – Isotropic Turbulence and Homogeneous Turbulence – Kinematics of Isotropic Turbulence – Taylor's Hypothesis – Dynamics of Isotropic Turbulence – Grid Turbulence and decay – Turbulence in Stirred Tanks.

UNIT V TURBULENT FLOWS 9

WALL Turbulent shear flows – Structure of wall flow – Turbulence characteristics of Boundary layer – Free Turbulence shear flows – Jets and wakes – Plane and axi-symmetric flows.

TOTAL : 45 PERIODS

TEXT BOOKS:

1. G. Biswas and E. Eswaran, Turbulent Flows, Fundamentals, Experiments and Modelling, Narosa Publishing House, 2002.
2. H. Schlichting and Klaus Gersten, Boundary Layer Theory, Springer 2000.
3. R.J. Garde, Turbulent Flow, New Age International (p) Limited, Publishers, 2000.

IC 9268 **FUEL CELL TECHNOLOGY** **L T P C**
3 0 0 3

OBJECTIVE:

To gain insight about fuel cells, their working principle, types of fuel cells and performance analysis.

UNIT I INTRODUCTION 5

Basic Principles – Classification – Alkaline, Proton Exchange Membrane, Direct Methanol, Phosphoric Acid & Molten Carbonate – Parts – Fuel cell poisoning

UNIT II THERMODYNAMICS 12

Basic Reactions, Heat of reaction, Enthalpy of formation of substances – Enthalpy change of a reacting system – Gibbs free energy of substances – Gibbs free energy change of reacting system – Efficiency – Power, heat due to entropy change, and internal ohmic heating

UNIT III ELECTROCHEMISTRY 13

Nernst equation and open circuit potential, pressure effect, temperature effect – Stoichiometric coefficients and reactants utilization – Mass flow rate calculation – voltage and current in parallel and serial connection – Over-potentials and polarizations – Activation polarization – Tafel equation and exchange current density – Ionic conductivity, catalysts, Temperature and humidification effect, electro-osmotic drag effect

UNIT IV DESIGN & OPTIMISATION 10

Geometries of fuel cells and fuel cell stacks – Rate of Diffusion of reactants – Water flooding and water management – Gas delivery and current collection – Bipolar plates design – Flow uniformity consideration – Optimization of gas delivery and current collection/asymptotic power density-Heat Removal from Stack

UNIT V APPLICATIONS 5

Automotive applications & issues – Micro fuel cells & Portable power – Distributed & Stationary power.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Fuel Cell Systems Explained, James Larminie and Andrew Dicks, 2nd Edition, John Wiley & Sons Inc., 2000.
2. PEM Fuel Cells Theory and Practice, Frano Barbir, Elsevier Academic Press, 2005.

TE 9266 **DESIGN OF THERMAL SYSTEMS** **L T P C**
3 0 0 3

AIM:

To provide review and use knowledge from thermodynamics, heat transfer and fluid mechanics, modeling and stimulation techniques for thermal system component analysis and their synthesis in integral engineering systems and processes

OBJECTIVE:

- To learn basic principles underlying piping, pumping, heat exchangers; modeling and optimization in design of thermal systems.
- To develop representational modes of real processes and systems.
- To optimization concerning design of thermal systems.

UNIT I DESIGN CONCEPTS **9**

Design Principles , Workable Systems , Optimal Systems , Matching of System Components , Economic Analysis , Depreciation , Gradient Present Worth factor.

UNIT II MATHEMATICAL MODELLING **9**

Equation Fitting , Nomography , Empirical Equation , Regression Analysis , Different Modes of Mathematical Models , Selectio n, Computer Programmes for Models.

UNIT III MODELLING THERMAL EQUIPMENTS **10**

Modelling Heat Exchangers , Evaporators , Condensers , Absorption and Rectification Columns , Compressors , Pumps , Simulation Studies , Information Flow Diagram , Solution Procedures.

UNIT IV OPTIMIZATION **12**

Objective Function Formulation , Constraint Equations , Mathematical Formulation , Calculus Method , Dynamic Programming , Search Methods , ANN and Genetic Algorithm.

UNIT V DYNAMIC BEHAVIOUR **5**

Steady state Simulation , Laplace Transformation , Feedback Control Loops , Stability Analysis , Non-Linearities.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Stoecker W. F., Design of Thermal Systems , McGraw Hill Edition , 1989.
2. Bejan A., George Tsatsaronis , Michael J. Moran , Thermal Design and Optimization , Wiley , 1996.

REFERENCES:

1. Kapur J. N., Mathematical Modelling , Wiley Eastern Ltd , New York , 1989.
2. Yogesh Jaluria , Design and Optimization of Thermal Systems , CRC Press , 2007.
3. Rao S. S., Engineering Optimization Theory and Practice , New Age Publishers , 2000.

TE 9268 COMBUSTION ENGINEERING L T P C
3 0 0 3

AIM :

To introduce the types, characterization and properties of fuel, Also to discuss the principles of combustion with emphasis on engineering applications.

OBJECTIVES :

- To provide information on various types of fuels, their property and characterization.
- To understand the thermodynamics and kinectics of combustion.
- To understand and analyze the combustion of various fuels.

UNIT I INTRODUCTION 9

Historical perspective of combustion science – perspective of fuels and combustion technology. Types and general characteristics of fuels – proximate and ultimate analysis of fuels. ROM, DMMF, DAF and bone dry basis. Moisture and heating value determination – gross and net hearting values – claorimetry, DuLong's formula for HV estimation, Flue gas analysis – Orsat apparatus.

UNIT II FUEL TYPES 9

Solid Fuels :

Peat – coal – biomass – wood waste – agro fuels – refuse derived solid fuel – testing of solid fuels. Bulk and apparent density – storage – washability – coking and caking coals.

Liquid Fuels :

Refining – molecular structure – liquid fuel types and their characteristics – fuel quality. Liquefaction of solid fuels.

Gaseous Fuels :

Classification and characterization.

UNIT III THERMODYNAMICS AND KINETICS OF COMBUSTION 9

Properties of mixture – combustion stoichiometry – chemical energy – chemical equilibrium and criteria – properties of combustion products. First law combustion calculations – adiabatic flame temperature (analytical and graphical methods) – simple second law analysis. Elementary reactions – chain reactions – pre-ignition kinetics – global reactions – kinectics – reaction at solid surface.

UNIT IV COMBUSTION OF SOLID FUELS 8

Drying - devolatilization - char combustion. Fixed bed combustion - suspension burning - fluidized bed combustion.

UNIT V COMBUSTION OF LIQUID AND GASEOUS FUELS 10

Spray formation and droplet behaviour - oil fired furnace combustion - gas turbine spray combustion – direct and indirect Injection combustion in IC engines.Energy balance and furnace efficiency – gas burner types - pulse combustion furnace.Premixed charge engine combustion.Detonation of gaseous mixtures.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Kuo, K.K., Principles of Combustion, 2nd Edition, John Wiley and Sons, Inc., 2005.
2. Annamalai, K and Puri, I.K, Combustion science and Engineering, CRC Press, 2007.

REFERENCES:
1. Borman, G.L. and Ragland, K.W., Combustion Enginnering, McGrawHill International Editions, 1998.
2. Samir Sarkar, Fuels and Combustion, 2nd Edition, Orient Longman, 1990
3. Sharma SP and Mohan Chander, Fuels and Combustion, Tata Mcgraw Hill, 1984.
4. Bhatt, B.I and Vora, S.M., Stoichiometry, 2nd Edition, Tata Mcgraw Hill, 1996
5. Clive Davis, Calculations in Furnace Technology, Pergamon Press, Oxford, 1970.

TE 9269 ENERGY CONSERVATION IN THERMAL SYSTEMS L T P C
3 0 0 3

AIM :

To course is intended to introduce principles of energy auditing and to provide measures for energy conservation in thermal applications

OBJECTIVE :

- To learn the present energy scenario and the need for energy conservation
- To learn the instruments suitable for energy auditing
- To study the various measures for energy conservation and financial implications for various thermal utilities

UNIT I INTRODUCTION 10

Energy Scenario – world and India. Energy Resources Availability in India. Energy consumption pattern. Energy conservation potential in various Industries and commercial establishments. Energy intensive industries – 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 2003.

UNIT II INSTRUMENTS FOR ENERGY AUDITING 8

Instrument characteristics – sensitivity, readability, accuracy, precision, hystersis. Error and calibration. Measurement of flow, velocity, pressure, temperature, speed, Lux, power and humidity. Analysis of stack, water quality, power and fuel quality.

UNIT III THERMAL UTILITIES: OPERATION AND ENERGY CONSERVARTION 10

(i) Boilers (ii) Thermic Fluid Heaters (iii) Furnaces
(iv) Waste Heat Recovery Systems (v) Thermal Storage

UNIT IV THERMAL ENERGY TRANSMISSION / PROTECTION SYSTEMS 7

Steam traps – refractories – optimum insulation thickness – insulation – piping design

UNIT V FINANCIAL MANAGEMENT 10

Investment – need, appraisal and criteria, financial analysis techniques – break even analysis – simple pay back period, return on investment, net present value, internal rate of return, cash flows, DSCR, financing options, ESCO concept.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Smith, CB Energy Management Principles, Pergamon Press, NewYork, 1981
2. Hamies, Energy Auditing and Conservation; Methods Measurements, Management and Case study, Hemisphere, Washington, 1980

REFERENCES:

1. Trivedi, PR, Jolka KR, Energy Management, Commonwealth Publication, New Delhi, 1997
2. Write, Larry C, Industrial Energy Management and Utilization, Hemisphere Publishers, Washington, 1988
3. Diamant, RME, Total Energy, Pergamon, Oxford, 1970
4. Handbook on Energy Efficiency, TERI, New Delhi, 2001
5 .Guide book for National Certification Examination for Energy Managers and Energy Auditors (Could be downloaded from www.energymanagertraining.com)

TE 9270 ADVANCED POWER PLANT ENGINEERING L T P C
3 0 0 3

AIM:

To introduce the advances in operations and applications of different types of power plants.

OBJECTIVE:

- To understand the energy scenario and the environmental issues related to the power plants.
- To understand the various improvements possible in steam turbine, gas turbine
- and combined cycle power plants.
- To study the advances in nuclear and MHD power plants.

UNIT I INTRODUCTION 6

Overview of the Indian power sector – load curves for various applications – types of power plants – merits and demerits – criteria for comparison and selection.

UNIT II STEAM AND GAS TURBINE POWER PLANTS 12

Rankine Cycle – Performance – thermodynamic analysis of cycles. Cycle improvements. Superheaters, reheaters – condenser and feed water heaters – operation and performance – layouts. Gas turbine cycles – optimization – thermodynamic analysis of cycles – cycle improvements – multi spool arrangement. Intercoolers, reheaters, regenerators – operation and performance – layouts.

UNIT III ADVANCED POWER CYCLES 10

Binary and combined cycle – coupled cycles – comparative analysis of combined heat and power cycles – IGCC – AFBC/PFBC cycles – Thermionic steam power plant.

UNIT IV 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.

UNIT V ENVIRONMENTAL ISSUES 7

Air and water pollution – acid rains – thermal pollution – radioactive pollution – standardization – methods of control. Environmental legislations / Government policies. Economics of power plants.

TOTAL : 45 PERIODS

TEXT BOOKS:

1. Nag, P.K., Power Plant Engineering, Tata Mcgraw Hill Publishing Co Ltd, New Delhi, 1998.
2. Arora and Domkundwar, A course in power Plant Engineering, Dhanpat Rai and CO, 2004.

REFERENCES:

1. Haywood, R.W., Analysis of Engineering Cycles, 4th Edition, Pergamon Press, Oxford, 1991.
2. Wood, A.J., Wollenberg, B.F., Power Generation, operation and control, John Wiley, New York,1984.
3. Gill, A.B., Power Plant Performance, Butterworths, 1984.
4. Lamarsh, J.R., Introduction to Nuclear Engg.2nd edition, Addison-Wesley, 1983.

TE 9271 STEAM GENERATOR TECHNOLOGY L T P C
3 0 0 3

AIM:

To understand the types, working of steam generator and their major components, along with design principles and calculations.

OBJECTIVES:

- To educate the students on the types of boilers with their constructional and functional significance.
- To understand the working and design of coal preparation units and boilers.
- To introduce the concept of heat transfer surfaces and the boiler design.

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 BOILERS 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

TEXT BOOKS:

1. Prabir Basu, Cen Kefa and Louis Jestin, Boilers and Burners: Design and Theory, Springer 2000.
2. Ganapathy, V., Industrial Boilers and Heat Recovery Steam Generators, Marcel Dekker Ink 2003

REFERENCES:

1. David Gunn and Robert Horton, Industrial Boilers, Longman Scientific and Technical Publication, 1986
2. Carl Schields, Boilers: Type, Characteristics and Functions, McGraw Hill Publishers, 1982
3. Howard, J.R., Fluidized Bed Technology: Principles and Applications, Adam Hilger, New York, 1983.

TE 9272 FLUIDIZED BED SYSTEMS L T P C
3 0 0 3

AIM:

To inspire the students with the theories of fluidization, heat transfer and design for various applications.

OBJECTIVE:

- To introduce the concepts of fluidization and heat transfer in fluidized beds.
- To understand the design principles and apply the same for industrial applications.

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 – 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

TEXT BOOKS:

1. Howard,J.R.,Fluidized Bed Technology:Principles and Applications,Adam Hilger, NewYork, 1983.
2. Geldart, D., Gas Fluidization Technology, John Willey and Sons, 1986.

REFERENCES:

1. Kunii, D and Levespiel, O., Fluidization Engineering, John Wiley and Son Inc, New York, 1969.
2. Howard, J.R. (Ed), Fluidized Beds: Combustion and Applications, Applied Science Publishers, NewYork, 1983.
3 . Botteril, J.S.M., Fluid Bed Heat Transfer, Academic Press, London, 1975.
4. Yates, J.G.Fundamentals of Fluidized bed Chemical Processes, Butterworths, 1983.

EY 9256 **DESIGN OF HEAT EXCHANGERS** **L T P C**
3 0 0 3

AIM:
The course is intended to build up necessary background for the design of the various types of heat exchangers.

OBJECTIVE:
- To learn the thermal and stress analysis on various parts of the heat exchangers
- To analyze the sizing and rating of the heat exchangers for various applications

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

TEXT BOOKS:

1. Sadik Kakac and Hongtan Liu, Heat Exchangers Selection, Rating and Thermal Design, CRC Press, 2002

REFERENCES
1. Arthur. P Frass, Heat Exchanger Design, John Wiley & Sons, 1988.
2. Taborek.T, Hewitt.G.F and Afgan.N, Heat Exchangers, Theory and Practice, McGraw-Hill Book Co. 1980.
3. Hewitt.G.F, Shires.G.L and Bott.T.R, Process Heat Transfer, CRC Press, 1994.

TE 9274 ADVANCED THERMAL STORAGE TECHNOLOGIES L T P C
3 0 0 3

AIM:

This course is intended to build up the necessary background to model and analyze the various types of thermal storage systems

OBJECTIVES:

- To learn the various types of thermal storage systems and the storage materials
- To develop the ability to model and analyze the sensible and latent heat storage units
- To study the various applications of thermal storage systems

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 – use of TRNSYS – 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

TEXT BOOKS:

1. Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons 2002.

REFERENCES:

1. Schmidt.F.W and Willmott.A.J, Thermal Storage and Regeneration, Hemisphere Publishing Corporation, 1981.
2. Lunardini.V.J, Heat Transfer in Cold Climates, John Wiley and Sons 1981.