

ANNA UNIVERSITY, CHENNAI
AFFILIATED INSTITUTIONS
REGULATIONS 2013
M.E. THERMAL ENGINEERING

I TO IV SEMESTERS (FULL TIME) CURRICULUM AND SYLLABUS

SEMESTER I

COURSE CODE	COURSE TITLE	L	T	P	C
THEORY					
MA7169	Advanced Numerical Methods	3	1	0	4
TE7101	Advanced Heat Transfer	3	1	0	4
TE7102	Advanced Thermodynamics	3	1	0	4
TE7103	Advanced Engineering Fluid Mechanics	3	0	0	3
TE7104	Fuels and Combustion	3	0	0	3
	Elective I	3	0	0	3
PRACTICAL					
TE7111	Thermal Engineering Laboratory	0	0	3	2
TOTAL		18	3	3	23

SEMESTER II

COURSE CODE	COURSE TITLE	L	T	P	C
THEORY					
TE7201	Design of Thermal Systems	3	0	0	3
TE7202	Instrumentation for Thermal Engineering	3	0	0	3
TE7203	Environmental Engineering and Pollution Control	3	0	0	3
	Elective II	3	0	0	3
	Elective III	3	0	0	3
	Elective IV	3	0	0	3
PRACTICAL					
TE7211	Seminar I	0	0	2	1
TE7212	Simulation Laboratory	0	0	3	2
TOTAL		18	0	5	21

SEMESTER III

COURSE CODE	COURSE TITLE	L	T	P	C
THEORY					
	Elective V	3	0	0	3
	Elective VI	3	0	0	3
	Elective VII	3	0	0	3
PRACTICAL					
TE7311	Seminar II	0	0	2	1
TE7312	Project work (Phase I)	0	0	12	6
TOTAL		9	0	14	16

SEMESTER IV

COURSE CODE	COURSE TITLE	L	T	P	C
TE7411	Project Work (Phase II)	0	0	24	12
TOTAL		0	0	24	12

TOTAL CREDITS TO BE EARNED FOR THE AWARD OF THE DEGREE =72

LIST OF ELECTIVES FOR M.E THERMAL ENGINEERING

SEMESTER I (Elective I)

COURSE CODE	COURSE TITLE	L	T	P	C
TE7001	Design of Heat Exchangers	3	0	0	3
IC7003	Aircraft and Space Propulsion	3	0	0	3
EY7003	Hydrogen and Fuel Cell Technologies	3	0	0	3
EY7103	Energy Resources	3	0	0	3
IC7071	Advanced Internal Combustion Engineering	3	0	0	3
TE7002	Cryogenic Engineering	3	0	0	3
TE7003	Refrigeration Machinery and Components	3	0	0	3

SEMESTER II (Elective II, III & IV)

COURSE CODE	COURSE TITLE	L	T	P	C
IC7072	Computational Fluid Dynamics	3	0	0	3
TE7004	Fans, Blowers and Compressors	3	0	0	3
TE7005	Food Processing, Preservation and Transport	3	0	0	3
EY7008	Nuclear Engineering	3	0	0	3
TE7006	Industrial Refrigeration Systems	3	0	0	3
TE7007	Refrigeration Systems Design	3	0	0	3
TE7008	Energy Management in Thermal Systems	3	0	0	3

SEMESTER III (Elective V, VI & VII)

COURSE CODE	COURSE TITLE	L	T	P	C
EY7202	Design and Analysis of Turbomachines	3	0	0	3
TE7009	Boundary Layer Theory and Turbulence	3	0	0	3
TE7010	Advanced Power Plant Engineering	3	0	0	3
EY7010	Steam Generator Technology	3	0	0	3
EY7011	Fluidized Bed Systems	3	0	0	3
TE7011	Advanced Thermal Storage Technologies	3	0	0	3
TE7012	Cogeneration and Waste Heat Recovery Systems	3	0	0	3

AIM:**OBJECTIVE:**

To impart knowledge on numerical methods that will come in handy to solve numerically the problems that arise in engineering and technology. This will also serve as a precursor for future research.

UNIT I ALGEBRAIC EQUATIONS (9+3)

Systems of linear equations: Gauss Elimination method, pivoting techniques, Thomas algorithm for tridiagonal system – Jacobi, Gauss Seidel, SOR iteration methods - Systems of nonlinear equations: Fixed point iterations, Newton Method, Eigenvalue problems: power method, inverse power method, Faddeev – Leverrier Method.

UNIT II ORDINARY DIFFERENTIAL EQUATIONS (9+3)

Runge Kutta Methods for system of IVPs, numerical stability, Adams-Bashforth multistep method, solution of stiff ODEs, shooting method, BVP: Finite difference method, orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method.

UNIT III FINITE DIFFERENCE METHOD FOR TIME DEPENDENT PARTIAL DIFFERENTIAL EQUATION (9+3)

Parabolic equations: explicit and implicit finite difference methods, weighted average approximation - Dirichlet and Neumann conditions – Two dimensional parabolic equations – ADI method; First order hyperbolic equations – method of characteristics, different explicit and implicit methods; numerical stability analysis, method of lines – Wave equation: Explicit scheme- Stability of above schemes.

UNIT IV FINITE DIFFERENCE METHODS FOR ELLIPTIC EQUATIONS (9+3)

Laplace and Poisson's equations in a rectangular region: Five point finite difference schemes, Leibmann's iterative methods, Dirichlet and Neumann conditions – Laplace equation in polar coordinates: finite difference schemes – approximation of derivatives near a curved boundary while using a square mesh.

UNIT V FINITE ELEMENT METHOD (9+3)

Partial differential equations – Finite element method - orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method.

TOTAL (L – 45 + T – 15): 60 PERIODS

OUTCOME:

- It helps the students to get familiarized with the numerical methods which are necessary to solve numerically the problems that arise in engineering.

REFERENCES

1. Saumyen Guha and Rajesh Srivastava, "Numerical methods for Engineering and Science", Oxford Higher Education, New Delhi, 2010.
2. Gupta S.K., "Numerical Methods for Engineers", New Age Publishers, 1995
3. Burden, R.L., and Faires, J.D., "Numerical Analysis – Theory and Applications", Cengage Learning, India Edition, New Delhi, 2009.
4. Jain M. K., Iyengar S. R., Kanchi M. B., Jain , "Computational Methods for Partial Differential Equations", New Age Publishers, 1993.
5. Morton K.W. and Mayers D.F., "Numerical solution of partial differential equations", Cambridge University press, Cambridge, 2002.

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 exchangers.
- 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 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 - – 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

OUTCOME:

- On successful completion of this course the student will be able to apply the law of thermodynamics to engines.

REFERENCES

1. Yunus A.Cengal, Heat and Mass Transfer – A practical Approach, 3rd edition, Tata McGraw - Hill, 2007.
2. Holman.J.P, Heat Transfer, Tata Mc Graw Hill, 2002.
3. Ozisik. M.N., Heat Transfer – A Basic Approach, McGraw-Hill Co., 1985
4. Incropera F.P. and DeWitt. D.P., Fundamentals of Heat & Mass Transfer, John Wiley & Sons, 2002.
5. Nag.P.K, Heat Transfer, Tata McGraw-Hill, 2002
6. Ghoshdastidar. P.S., Heat Transfer, Oxford University Press, 2004
7. Yadav, R., Heat and Mass Transfer, Central Publishing House, 1995.

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 – Dirac and Bose – Einstein statistics - microscopic interpretation of heat and work, evaluation of entropy, partition 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 Jr., Advanced Thermodynamics for Engineers, McGraw – Hill Inc., 1995.
2. Bejan, A., Advanced Engineering Thermodynamics, John Wiley and Sons, 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 Thermodynamics, 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. DeHoff, R.T., Thermodynamics in Materials Science, McGraw – Hill Inc., 1993. Rao, Y.V.C., Postulational and Statistical Thermodynamics, Allied Publisher Limited, New Delhi, 1999.

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 irrotational flows - circulation – vorticity - stream and potential functions for standard flows and combined flows – representation of solid bodies by flow patterns. Pressure distribution over stationary 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 Okishi, T.H., Fundamentals of Fluid Mechanics, John Wiley and Sons Inc., New York, 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.

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

TE7111

THERMAL ENGINEERING LABORATORY

L T P C
0 0 3 2

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

TOTAL: 45 PERIODS

TE7201

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 simulation 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 , Selection, 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**OUTCOME:**

On successful Completion of this course the student will be understand modeling and optimization of Thermal systems.

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.

REFERENCE:

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.

TE7202**INSTRUMENTATION FOR THERMAL ENGINEERING****L T P C
3 0 0 3****AIM:**

To enhance the knowledge of the students about various measuring instruments, techniques and importance of error and uncertainty analysis.

OBJECTIVES:

- (I) To provide knowledge on various measuring instruments.
- (II) To provide knowledge on advance measurement techniques.
- (III) To understand the various steps involved in error analysis and uncertainty analysis.

UNIT I MEASUREMENT CHARACTERISTICS**12**

Instrument Classification, Characteristics of Instruments – Static and dynamic, experimental error analysis, Systematic and random errors, Statistical analysis, Uncertainty, Experimental planning and selection of measuring instruments, Reliability of instruments.

UNIT II MICROPROCESSORS AND COMPUTERS IN MEASUREMENT**5**

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

UNIT III MEASUREMENT OF PHYSICAL QUANTITIES**10**

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

UNIT IV ADVANCE MEASUREMENT TECHNIQUES**8**

Shadowgraph, Schlieren, Interferometer, Laser Doppler Anemometer, Hot wire Anemometer, heat flux sensors, Telemetry in measurement.

UNIT V MEASUREMENT ANALYSERS**10**

Orsat apparatus, Gas Analysers, Smoke meters, gas chromatography, spectrometry.

TOTAL: 45 PERIODS

TEXT BOOKS :

1. Holman, J.P., Experimental methods for engineers, McGraw-Hill, 1988.
2. Barney, Intelligent Instrumentation, Prentice Hall of India, 1988.
3. Prebrashensky, V., Measurements and Instrumentation in Heat Engineering, Vol. 1 and 2, MIR Publishers, 1980.

REFERENCES

1. Raman, C.S., Sharma, G.R., Mani, V.S.V., Instrumentation Devices and Systems, Tata McGraw-Hill, New Delhi, 1983.
2. Holman, J.P., Experimental methods for engineers, McGraw-Hill, 1958.
3. Barney, Intelligent Instrumentation, Prentice Hall of India, 1988
4. Prebrashensky. V., Measurement and Instrumentation in Heat Engineering, Vol.1 and MIR Publishers, 1980.
5. Raman, C.S. Sharma, G.R., Mani, V.S.V., Instrumentation Devices and Systems,
6. Tata McGraw-Hill, New Delhi, 1983.
7. Doebelin, Measurement System Application and Design, McGraw-Hill, 1978.
8. Morris. A.S, Principles of Measurements and Instrumentation Prentice Hall of India, 1998.

TE7203

ENVIRONMENTAL ENGINEERING AND POLLUTION CONTROL

**L T P C
3 0 0 3**

AIM:

To create awareness among the student community on anthropogenic degradation of environment and technologies available to limit the degradation.

OBJECTIVES:

- To impart knowledge on the atmosphere and its present condition, global warming and eco-legislations.
- To detail on the sources of air, water and noise pollution and possible solutions for mitigating their degradation.
- To elaborate on the technologies available for generating energy from waste.

UNIT I INTRODUCTION

9

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

UNIT II AIR POLLUTION

9

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

UNIT III WATER POLLUTION

9

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

UNIT IV WASTE MANAGEMENT

9

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

UNIT V OTHER TYPES OF POLLUTION FROM INDUSTRIES

9

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

TOTAL: 45 PERIODS

TEXT BOOKS:

1. G.Masters (2003): Introduction to Environmental Engineering and Science Prentice Hall of India Pvt Ltd, New Delhi.
2. H.S.Peavy, D.R..Rowe, G.Tchobanoglous (1985):Environmental Engineering McGraw- Hill BookCompany, NewYork.

REFERENCES:

1. H.Ludwig, W.Evans (1991): Manual of Environmental Technology in Developing Countries, . International Book Company, Absecon Highlands, N.J.
2. Arcadio P Sincero and G. A. Sincero, (2002): Environmental Engineering – A Design Approach, Prentice Hall of India Pvt Ltd, New Delhi.

TE7212

SIMULATION LABORATORY

L T P C
0 0 3 2

FOCUS: USE OF STANDARD APPLICATION SOFTWARE FOR SOLVING HEAT TRANSFER PROBLEMS

1. Heat exchanger analysis – NTU method
2. Heat exchanger analysis – LMTD method
3. Convection heat transfer analysis – Velocity boundary layer
4. Convection heat transfer analysis – Internal flow
5. Radiation heat transfer analysis – Emissivity
6. Critical radius of insulation
7. Lumped heat transfer analysis
8. Conduction heat transfer analysis
9. Condensation heat transfer analysis

DYNAMIC LINKING OF MAT LAB AND REF PROP SOFTWARE SIMPLE CFD PROBLEMS FOR PRACTICE

NOTE: The above exercises are only guidelines to maintain the standard for teaching and conduct of examination.

SIMULATION LAB – REQUIREMENT:

1. Software - Modeling software like ProE, Gambit, Ansys etc
Analysis software like Ansys, fluent, CFX, etc
Equation solving software like Matlab, Engg equation solver
1. Every students in a batch must be provided with a terminal
2. Hardware are compatible with the requirement of the above software.

TOTAL: 45 PERIODS

TE7001

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

OUTCOME

Able to design the heat exchanger based on the information provided for a particular application and do the cost economic analysis

TEXT BOOK:

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.

IC7003

AIRCRAFT AND SPACE PROPULSION

L T P C
3 0 0 3

AIM:

To enhance the knowledge of the students on aircrafts and space propulsion

OBJECTIVE S:

- 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 Mach Number and its influence and properties, Isentropic Flow, Rayleigh and Fanno Flow. Deflagration and Detonation – Normal shock and oblique shock waves.

UNIT II THERMODYNAMICS OF AIRCRAFT ENGINES**9**

Theory of Aircraft propulsion – Thrust – Various efficiencies – Different propulsion systems – Turbo-prop – Ram Jet – Turbojet, Turbojet with after burner, Turbo fan and Turbo shaft. Variable thrust- nozzles – vector control.

UNIT III PERFORMANCE CHARACTERISTICS 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 classification – rockets of propellants and Propellant Injection systems – Non-equilibrium expansion and supersonic combustion – Propellant feed systems – Reaction Control Systems - Rocket heat transfer.

TOTAL: 45 PERIODS**OUTCOME:**

On successful completion of this course the student will be able to understand the working of different types of aircraft and rocket propulsion systems and their performance characteristics.

REFERENCES

- Philip G. Hill and Carl R. Peterson, Mechanics and Thermodynamics of Propulsion, Second Edition, Addition – Wesley Publishing Company, New York, 2009.
- Zucrow N.J. Principles of Jet Propulsion and Gas Turbines, John Wiley and Sons New York, 1970.
- Zucrow N.J. Aircraft and Missile Propulsion, Vol. I and Vol. II, John Wiley and Sons Inc, New York, 1975.
- S. M.Yahya, Fundamentals of Compressible Flow. Third edition, New Age International Pvt Ltd, 2003.
- Bonney E.A. Zucrow N.J. Principles of Guided Missile Design, Van Nostranc Co., 1956.

EY7003**HYDROGEN AND FUEL CELL TECHNOLOGIES****L T P C
3 0 0 3****AIM:**

To enlighten on various technological advancements, benefits and prospects of utilizing hydrogen/fuel cell for meeting the future energy requirements.

OBJECTIVES:

- To explain concept of various forms of Non-renewable and renewable energy
- To outline division aspects and utilization of renewable energy sources for both domestic and industrial applications
- To analysis the environmental and cost economics of using renewable energy sources compared to fossil fuels.

UNIT I COMMERCIAL ENERGY

9

Coal, Oil, Natural Gas, Nuclear power and Hydro - their utilization pattern in the past, present and future projections of consumption pattern - Sector-wise energy consumption – environmental impact of fossil fuels – Energy scenario in India – Growth of energy sector and its planning in India.

UNIT II SOLAR ENERGY

9

Solar radiation at the earth's surface – solar radiation measurements – estimation of average solar radiation - solar thermal flat plate collectors - concentrating collectors – solar thermal applications - heating, cooling, desalination, drying, cooking, etc – solar thermal electric power plant - principle of photovoltaic conversion of solar energy, types of solar cells - Photovoltaic applications: battery charger, domestic lighting, street lighting, water pumping etc - solar PV power plant – Net metering concept.

UNIT III WIND ENERGY

9

Nature of the wind – power in the wind – factors influencing wind – wind data and energy estimation - wind speed monitoring - wind resource assessment - Betz limit - site selection - wind energy conversion devices - classification, characteristics, applications – offshore wind energy - Hybrid systems - safety and environmental aspects – wind energy potential and installation in India - Repowering concept.

UNIT IV BIO-ENERGY

9

Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - direct combustion – biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - types of biogas Plants - applications - alcohol production from biomass – bio diesel production – Urban waste to energy conversion - Biomass energy programme in India.

UNIT V OTHER TYPES OF ENERGY

9

Ocean energy resources - principle of ocean thermal energy conversion (OTEC) - ocean thermal power plants - ocean wave energy conversion - tidal energy conversion – small hydro - geothermal energy - geothermal power plants – hydrogen production and storage - Fuel cell – principle of working - various types - construction and applications.

TOTAL HOURS : 45 PERIODS

OUTCOME:

- Understanding of commercial energy and renewable energy sources
- Knowledge in working principle of various energy systems
- Capability to do basic design of renewable energy systems

REFERENCES

1. Sukhatme, S.P., Solar Energy, Tata McGraw Hill, 1984.
2. Twidell, J.W. and Weir, A., Renewable Energy Sources, EFN Spon Ltd., 1986.
3. Kishore VVN, Renewable Energy Engineering and Technology, Teri Press, New Delhi, 2012
4. Peter Gevorkian, Sustainable Energy Systems Engineering, McGraw Hill, 2007
5. Kreith, F and Kreider, J. F., Principles of Solar Engineering, McGraw-Hill, 1978.
6. Godfrey Boyle, Renewable Energy, Power for a Sustainable Future, Oxford University Press, U.K, 1996.

7. Veziroglu, T.N., Alternative Energy Sources, Vol 5 and 6, McGraw-Hill, 1990
8. Anthony San Pietro, Biochemical and Photosynthetic aspects of Energy Production, Academic Press, 1980.
9. Bridgurater, A.V., Thermochemical processing of Biomass, Academic Press, 1981.
10. Bent Sorensen , Renewable Energy, Elsevier, Academic Press, 2011

IC7071 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 : 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

TE7002 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

TE7003 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>

IC7072 COMPUTATIONAL FLUID DYNAMICS L T P C
3 0 0 3

AIM:

This course aims to introduce numerical modeling and its role in the field of heat and fluid flow, it will enable the students to understand the various discrimination methods and solving methodologies and to create confidence to solve complex problems in the field of heat transfer and fluid dynamics.

OBJECTIVE S:

- To develop finite difference and finite volume discredited forms of the CFD equations.
- To formulate explicit & implicit algorithms for solving the Euler Eqns & Navier Stokes Eqns.

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 – Vorticity 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, $k - \epsilon$ 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. Ghoshdasdar, 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.

TE7004 FANS, BLOWERS AND 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>

TE7005 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. Ibrahim 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.

EY7008

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 – Beryllium

UNIT III REPROCESSING

9

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

UNIT IV SEPARATION OF REACTOR PRODUCTS

9

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

UNIT V WASTE DISPOSAL AND RADIATION PROTECTION

9

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

TOTAL HOURS : 45 PERIODS

OUTCOME

- Understanding fundamentals of nuclear reactions
- Knowledge in nuclear fission chain reaction and fusion
- Awareness about reprocessing of spent fuel and waste disposal

REFERENCES

1. Glasstone, S. and Sesonske, A, Nuclear Reactor Engineering, 3rd Edition, Von Nostrand, 1984.
2. J. Kenneth Shultis, Richard E, Faw, Richard E. Faw, Fundamentals of Nuclear Science and Engineering, CRC Press, 2008
3. Tatjana Tevermovic, Nuclear Principles in Engineering, Springer, 2008
4. Kenneth D. Kok, Nuclear Engineering, CRC Press, 2009
5. Cacuci, Dan Gabriel, Nuclear Engineering Fundamentals, Springer, 2010
6. Lamarsh, J.R., Introduction to Nuclear Reactor Theory, Wesley, 1996.
7. Lalter, A.E. and Reynolds, A.B., Fast Breeder Reactor, Pergamon Press, 1981.
8. Winterton, R.H.S., Thermal Design of Nuclear Reactors, Pergamon Press, 1981.
9. Collier J.G., and G.F.Hewitt, " Introduction to Nuclear Power ", (1987), Hemisphere Publishing, New York.

TE7006	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 losses. 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.

TE7007

REFRIGERATION SYSTEMS DESIGN

L T P C
3 0 0 3

AIM:

To teach the students about Refrigeration System Design concepts.

OBJECTIVES:

- 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.

TE7008

ENERGY MANAGEMENT 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

OBJECTIVES:

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, hysteresis. 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 CONSERVATION 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, New York, 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)

**EY7202 DESIGN AND ANALYSIS OF TURBOMACHINES L T P C
3 0 0 3**

AIM:

To design and analyse the performance of Turbo machines for engineering applications.

OBJECTIVES:

- To understand 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 design various Turbomachines for power plant and aircraft applications

UNIT I	INTRODUCTION	12
Basics of isentropic flow – static and stagnation properties – diffuser and nozzle configurations - area ratio – mass flow rate – critical properties. Energy transfer between fluid and rotor velocity triangles for a generalized turbomachines - velocity diagrams. Euler’s equation for turbomachines and its different forms. Degree of reaction in turbo-machines – various efficiencies – isentropic, mechanical, thermal, overall and polytropic		
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 and losses		
UNIT III	COMBUSTION CHAMBER	6
Basics of combustion. Structure and working of combustion chamber – combustion chamber arrangements - flame stability – fuel injection nozzles. Flame stabilization - 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. Reheated, Regenerative and Intercooled cycles for power plants. Working of Turbojet, Turbofan, Turboprop, Ramjet, Scramjet and Pulsejet Engines and cycle analysis – thrust, specific impulse, specific fuel consumption, thermal and propulsive efficiencies.		

TOTAL : 45 PERIODS

OUTCOME:

When a student completes this subject, he / she can

- Understand the design principles of the turbomachines
- Analyse the turbomachines to improve and optimize its performance

REFERENCES

1. Ganesan, V., Gas Turbines, Tata McGrawHill, 2011.
2. Khajuria P.R and Dubey S.P., Gas Turbines and Propulsive Systems, Dhanpat Rai Publications, 2003
3. Cohen, H., Rogers, G F C and Saravanmotto, H I H, Gas Turbine Theory, John Wiley, 5th Edition 2001.
4. Hill P G and Peterson C R, Mechanics and Thermodynamics of Propulsion, Addition-Wesley, 1970.
5. Mattingly J D, Elements of Gas turbine Propulsion, McGraw Hill, 1st Edition. 1997

TE7009

BOUNDARY LAYER THEORY AND TURBULENCE

L T P C
3 0 0 3

AIM:

To enhance the students’ knowledge on boundary layer theory and turbulence

UNIT I	INTRODUCTION	5
Overview of Indian power sector – load curves for various applications – types of power plants – merits and demerits – criteria for comparison and selection - Economics of power plants.		
UNIT II	STEAM POWER PLANTS	9
Basics of typical power plant utilities - Boilers, Nozzles, Turbines, Condensers, Cooling Towers, Water Treatment and Piping system - Rankine Cycle – thermodynamic analysis. Cycle improvements – Superheat, Reheat, Regeneration		
UNIT III	DIESEL AND GAS TURBINE POWER PLANTS	9
I.C Engine Cycles - Otto, Diesel & Dual –Theoretical vis-à-vis actual – Typical diesel power plant – Types – Components - Layout - Performance analysis and improvement - Combustion in CI engines - E.C cycles – Gas turbine & Stirling - Gas turbine cycles – thermodynamic analysis – cycle improvements - Intercoolers, Re heaters, regenerators.		
UNIT IV	ADVANCED POWER CYCLES	12
Cogeneration systems – topping & bottoming cycles - Performance indices of cogeneration systems – Heat to power ratio - Thermodynamic performance of steam turbine cogeneration systems – gas turbine cogeneration systems – reciprocating IC engines cogeneration systems- Binary Cycle - Combined cycle – IGCC – AFBC / PFBC cycles – Thermionic steam power plant. MHD – Open cycle and closed cycle- Hybrid MHD & steam power plants		
UNIT V	HYDROELECTRIC & NUCLEAR POWER PLANTS	10
Hydroelectric Power plants – classifications - essential elements – pumped storage systems – micro and mini hydel power plants General aspects of Nuclear Engineering – Components of nuclear power plants - Nuclear reactors & types – PWR, BWR, CANDU, Gas Cooled, Liquid Metal Cooled and Breeder reactor - nuclear safety – Environmental issues		

TOTAL: 45 PERIODS

OUTCOME

- Possible mitigation of anthropogenic emissions by optimizing the power plant cycles/utilities

REFERENCES

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

EY7010	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 fuel preparation units and boilers.
- To introduce the concept of boiler design, emission aspects

UNIT I BASICS **8**
 Steam Cycle for Power Generation – Fuel Stoichiometry - Boiler Classification & Components – Specifications - Boiler Heat Balance – Efficiency Estimation (Direct & Indirect) – Sankey Diagram

UNIT II FUELS & BOILER TYPES **8**
 Solid Fuel : Coal Preparation – Pulverization – Fuel feeding arrangements , Fuel Oil : Design of oil firing system – components – Air regulators , Types of Boiler – Merits & Limitations – Specialty of Fluid Bed Boilers – Basic design principles (Stoker, Travelling Grate etc)

UNIT III COMPONENTS' DESIGN **12**
 Furnace – Water Wall – Steam Drum – Attemperator - Superheaters – Reheaters – Air Preheaters – Economisers - Steam Turbines : Design Aspects of all these

UNIT IV AUXILIARY EQUIPMENTS – DESIGN & SIZING **10**
 Forced Draft & Induced Draft Fans – PA / SA Fans – Water Pumps (Low Pressure & High Pressure) – Cooling Towers – Softener – DM Plant

UNIT V EMISSION ASPECTS **7**
 Emission Control – Low NO_x Burners– Boiler Blow Down - Control & Disposal : Feed Water Deaeration & Deoxygenation – Reverse Osmosis - Ash Handling Systems Design – Ash Disposal– Chimney Design to meet Pollution std – Cooling Water Treatment & Disposal

TOTAL: 45 PERIODS

OUTCOME:

1. Familiarization with Boiler cycles, components and will have specialized knowledge in steam boiler performance evaluation
2. Emission related aspects in terms of CO₂ NO_x emission, mitigation etc will make them to realize the impact of Coal / fuel burning in the society

REFERENCES

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

EY7011**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

OBJECTIVES:

- 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 – 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

OUTCOME:

When a student completes this subject, he / she can

- Understand the working principles, merits and limitations of fluidized bed systems
- Apply fluidized bed systems for a specific engineering applications
- Analyse the fluidized bed systems to improve and optimize its performance

REFERENCES

1. Howard, J.R., Fluidized Bed Technology: Principles and Applications, Adam Hilger, New York, 1983.
2. Geldart, D., Gas Fluidization Technology, John Wiley and Sons, 1986.
3. Kunii, D and Levespiel, O., Fluidization Engineering, John Wiley and Son Inc, New York, 1969.
4. Howard, J.R. (Ed), Fluidized Beds: Combustion and Applications, Applied Science Publishers, New York, 1983.
5. Botteril, J.S.M., Fluid Bed Heat Transfer, Academic Press, London, 1975.

TE7011	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 BOOK:

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.

TE7012 COGENERATION AND WASTE HEAT RECOVERY L T P C
SYSTEMS 3 0 0 3

AIM:

To detail on the importance of Total Energy Concept, its advantages and cost effectiveness.

OBJECTIVES:

- To analyze the basic energy generation cycles
- To detail about the concept of cogeneration, its types and probable areas of applications
- To study the significance of waste heat recovery systems and carryout its economic analysis

UNIT I INTRODUCTION 9
 Introduction – principles of thermodynamics – cycles – topping – bottoming – combined cycle – organic rankine cycles – performance indices of cogeneration systems – waste heat recovery – sources and types – concept of tri generation.

UNIT II CONGENERATION TECHNOLOGIES 9
 Configuration and thermodynamic performance – steam turbine cogeneration systems – gas turbine cogeneration systems – reciprocating IC engines cogeneration systems – combined cycles cogeneration systems – advanced cogeneration systems: fuel cell, Stirling engines etc.,

UNIT III ISSUES AND APPLICATIONS OF COGENERATION TECHNOLOGIES 9

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

UNIT IV WASTE HEAT RECOVERY SYSTEMS 9

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 – sorption systems.

UNIT V ECONOMIC ANALYSIS 9

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

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Charles H. Butler, Cogeneration, McGraw Hill Book Co., 1984.11
2. EDUCOGEN – The European Educational tool for cogeneration, Second Edition, 2001

REFERENCES:

1. Horlock JH, Cogeneration - Heat and Power, Thermodynamics and Economics, Oxford,1987.
2. Institute of Fuel, London, Waste Heat Recovery, Chapman & Hall Publishers,London, 1963.
3. Seagate Subrata, Lee SS EDS, Waste Heat Utilization and Management, Hemisphere, Washington, 1983.
4. De Nevers, Noel., Air Pollution Control Engineering, McGrawHill, New York,1995