ANNA UNIVERSITY TIRUCHIRAPPALLI

Tiruchirappalli – 620 024

Regulations 2008

Curriculum

M.E. THERMAL ENGINEERING

SEMESTER I

S.No	Subject Code	Subject	L	T	P	C
Theory						
1	**MA5142**	Applied Mathematics for Thermal Engineering	3	1	0	4
2	**IC5101**	Advanced Heat Transfer	3	1	0	4
3	**IC5102**	Advanced Thermodynamics	3	1	0	4
4	**IC5105**	Advanced Fluid Mechanics	3	0	0	3
5	**EY5102**	Fuels and combustion	3	0	0	3
6	**RA5101**	Refrigeration Systems Design	3	0	0	3
Practical						
7	**TH5103**	Thermal Engineering Laboratory	0	0	3	2
					Total	**23**

SEMESTER II

S.No	Subject Code	Subject	L	T	P	C
Theory						
1	**TH5151**	Advanced Internal Combustion Engineering	3	0	0	3
2	**IC5154**	Instrumentation for Thermal Systems	3	0	0	3
3	**EY5152**	Environmental Engineering and Pollution Control	3	0	0	3
4	**E1******	Elective I	3	0	0	3
5	**E2******	Elective II	3	0	0	3
6	**E3******	Elective III	3	0	0	3
Practical						
7	**TH5153**	Simulation Laboratory	0	0	3	2
					Total	**20**

SEMESTER III

S.No	Subject Code	Subject	L	T	P	C
Theory						
1	**E4******	Elective IV	3	0	0	3
2	**E5******	Elective V	3	0	0	3
3	**E6******	Elective VI	3	0	0	3
Practical						
4	**TH5251**	Project Work Phase I	0	0	12	6
					Total	**15**

SEMESTER IV

S.No	Subject Code	Subject	L	T	P	C
Practical						
1	**TH5251**	Project Wok Phase II	0	0	24	12
					Total	**12**

Total Credits to be Earned for the Award of the Degree = 70

ELECTIVES

S.No	Subject Code	Subject	L	T	P	C
Theory						
1	**EY5051**	Cogeneration and Waste Heat Recovery Systems	3	0	0	3
2	**EY5052**	Energy Systems Modeling and Analysis	3	0	0	3
3	**TH5051**	Advanced Power Plant Engineering	3	0	0	3
4	**IC5052**	Computational Fluid Dynamics	3	0	0	3
5	**EY5101**	Renewable Energy Systems	3	0	0	3
6	**RA5153**	Cryogenic Engineering	3	0	0	3
7	**RA5052**	Refrigeration Machinery and components	3	0	0	3
8	**RA5011**	Food Processing, Preservation and Transport	3	0	0	3
9	**TH5053**	Industrial Refrigeration Systems	3	0	0	3
10	**RA5053**	Fans, Blowers and Compressors	3	0	0	3

ANNA UNIVERSITY TIRUCHIRAPPALLI
Tiruchirappalli - 620 024
Regulations 2008
Syllabus

M.E. THERMAL ENGINEERING

SEMESTER I

MA5142 – APPLIED MATHEMATICS FOR THERMAL ENGINEERING

(Common to Thermal Engineering, Energy Engineering and Refrigeration & Air-Conditioning)

L	T	P	C
3	1	0	4

UNIT I FOURIER TRANSFORMS 9

Fourier Transforms – Complex, Sine and Cosine Transforms – Finite Fourier Transforms – Applications – One dimensional heat conduction problem – Laplace Equation – Poison Equation.

UNIT II CALCULUS OF VARIATIONS 8

Variation and its properties – Euler's equation – Functional dependent on first and higher order derivatives – Functional dependent on functions of several independent variables – Some applications – 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 – Application to fluid flow – Application to heat flow.

UNIT IV SOLUTIONS OF LINEAR SYSTEMS OF EQUATIONS 10

Matrix transformations – Direct methods – Gaussian Elimination method, Gauss modern method, Factorisation method – Iterative methods – Jacobi, Gauss Seidely and SOR methods.

UNIT V NUMERICAL SOLUTION OF PDE 9

Solution of Laplace's and Poission equation on a rectangular region by Liebmann's method – Diffusion equation by the explicit and Crank Nicolson – Implicit methods – Stability and Convergence criterion – Solution of wave equation by explicit scheme.

L: 45 T: 15 Total: 60

REFERENCES

1. Sneddon, I.N., “Elements of Partial Differential Equations”, McGraw-Hill, 1986.
2. Spiegel, M.R., “Theory and Problems of Complex variables with an Introduction to conformal mapping and its applications”, Schaum’s outline series, McGraw-Hill Book Co., 1987.
3. Sankara Rao, K., “Introduction to Partial Differential Equations”, Prentice–Hall of India, 1995
4. Elsgolts, L., “Differential Equation and Calculus of Variations”, Mir Publishers, 1996.
5. Carnanan. B., Luther. H.A., and Wilkes, J.O., “Applied Numerical Methods”, Wiley and Sons, 1976

IC5101 – ADVANCED HEAT TRANSFER

(Use of approved handbook permitted)

L	T	P	C
3	1	0	4

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 12

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 shear 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 10

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 5

Mass Transfer – Vaporization of droplets – Combined heat and mass transfer – Heat Transfer Correlations in various applications like I.C. Engines – Compressors & turbines

L: 45 T: 15 Total: 60

REFERENCES

1. Incropera F.P. and De Witt. D.P., “Fundamentals of Heat & Mass Transfer”, John Wiley & Sons, 1996.
2. Ozisik. M.N., “Heat Transfer – Basic Approach”, McGraw-Hill Co., 1985
3. Schlichting and Gersten, “Boundary layer Theory”, Springer, 2000
4. P.K. Nag, “Heat Transfer”, Tata McGraw-Hill, 2002
5. Rohsenow. W.M., Harnett. J.P., and Ganic. E.N., “Handbook of Heat Transfer Applications”, McGraw-Hill, 1985
6. Ghoshdasdidar. P.S., “Compiler simulation of flow and Heat Transfer”, Tata McGraw-Hill, 1998
7. Patankar. S.V., “Numerical Heat Transfer and Fluid Flow”, Hemisphere Publishing Corporation, 1980

IC5102 – ADVANCED THERMODYNAMICS

(Use of approved charts permitted)

L	T	P	C
3	1	0	4

UNIT I AVAILABILITY ANALYSIS AND THERMODYNAMIC PROPERTY RELATIONS 10

Availability, Irreversibility and Second-Law Efficiency for a closed System and steady-state Control Volume – Availability Analysis of Simple Cycles – Thermodynamic Potentials – Maxwell relations – Generalised relation for changes in Entropy – Internal Energy and Enthalpy – Generalised Relations for Cp and Cv Clausius Claypeyron Equation – Joule-Thomson Coefficient – Bridgman Tables for thermodynamic relations.

UNIT II REAL GAS BEHAVIOUS 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 prosperities – Real gas mixtures – Ideal solution of real gases and liquids – Equilibrium in multi phase systems – Gibbs phase rule for non-reactive components.

UNIT III CHEMICAL THERMODYNAMICS AND EQUILIBRIUM 10

Thermo chemistry – first Law analysis of reacting systems – Adiabatic Flame temperature – Entropy change of reacting systems – Second Law analysis of reacting systems – Criterion for reaction equilibrium composition.

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 Microscopic properties from partition functions.

UNIT V IRREVERSIBLE THERMODYNAMICS 7

Conjugate Fluxes and Forces – Entropy Production – Onsager's Reciprocity relations – thermo-electric phenomena and formulations.

L: 45 T: 15 Total: 60

REFERENCES

1. Kenneth Wark Jr., "Advanced Thermodynamics for Engineers", McGraw-Hill Inc., 1995.
2. Bejan, A., "Advanced Engineering Thermodynamics", John Wiley and Sons, 1998.
3. Holman, J.P., "Thermodynamics", Fourth Edition, McGraw-Hill Inc., 1998.
4. Sears, F.W. and Salinger G.I., "Thermodynamics, Kinetic Theory and Statistical Thermodynamics", Third Edition, Narosa Publishing House, 1993.
5. DeHoft, R.T., "Thermodynamics in Materials Science", McGraw-Hill Inc., 1993.
6. Rao, Y.V.C., "Postulational and Statistical Thermodynamics", Allied Publisher Limited, 1994.

IC5105 – ADVANCED FLUID MECHANICS

L	T	P	C
3	0	0	3

UNIT I INTRODUCTION 9

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

UNIT II TWO DIMENSIONAL FLOW 9

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

UNIT III TURBULENT FLOW 9

Turbulence – models and flow equations: steady and unsteady turbulent boundary layers

UNIT IV COMPRESSIBLE FLOW THROUGH DUCTS 9

Introduction to compressible viscous flow – governing equations – flow with friction – flow with neat transfer – flow though nozzle and diffuses

UNIT V SHOCK WAVE 9

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

Total: 45

REFERENCES

1. T Radhakrishnan "Gas Dynamics", Prentice Hall, 1993
2. Mohanty A K "Fluid Mechanics", Prentice Hall of India, 1986
3. Shapiro A F, "The Dynamics of Compressible flow Vol. 1", The Ronald Press Company, 1963.
4. Shames, "Mechanics of Fluids", MC Grow Hill Book company, 1962
5. Schlichting H, "Boundary layer theory", MC Grow Hill Book company, 1979

EY5102 – 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

REFERENCES

1. Samir Sarkar, “Fuels & Combustion”, Second Edition, Orient Longman, 1990
2. Bhatt, “Vora Stoichiometry’, Second Edition, Tata Mcgraw Hill, 1984
3. Blokh AG, “Heat Transfer in Steam Boiler Furnace”, Hemisphere Publishing Corp., 1988
4. Civil Davies, “Calculations in Furnace Technology”, Pergamon Press, Oxford, 1966
5. Sharma SP, Mohan Chander, “Fuels & Combustion”, Tata Mcgraw Hill, 1984

RA5101 – REFRIGERATION SYSTEMS DESIGN

L	T	P	C
3	0	0	3

UNIT I REFRIGERATION CYCLES - ANALYSIS 10

Carnot Cycle – Air Refrigeration Cycles – Vapor Compression Refrigeration Cycle from Basic – Analysis Multi-pressure Systems – Cascade Systems

UNIT II MAIN SYSTEM COMPONENTS 12

Compressors – condensers – evaporators – types and performance – Expansion devices – types and selection.

UNIT III REFRIGERANTS - HANDLING 6

Classification of Refrigerants – Refrigerant properties – Oil Compatibility – Environmental Impact – Montreal / Kyoto protocols – Eco Friendly Refrigerants

UNIT IV SYSTEM BALANCING & CONTROLS 11

Estimation of Cooling Load – System Equilibrium, balancing and matching of components – Cycling Controls – Electric Circuits in Refrigerators – Window A/C – Types of motors – Relays – Different Types of Refrigeration Tools – Evacuation and Charging Unit – Recovery and Recycling Unit – Vacuum Pumps.

UNIT V UNCONVENTIONAL REFRIGERATION CYCLES 6

Vapor Absorption Systems – Aqua Ammonia & LiBr Systems – Steam Jet Refrigeration Thermo Electric Refrigeration

Total: 45

REFERENCES

1. Dossat R.J., “Principles of refrigeration”, John Wiley, S.I. Version, 1989.
2. W.F. Stoecker, “Refrigeration and Air conditioning”, McGraw-Hill Book Company, 1989.
3. Jordan and Priester, “Refrigeration and Air conditioning”, 1985.
4. Goshnay W.B., “Principles and Refrigeration”, Cambridge, University Press, 1982.
5. Langley, Billy C., ‘Solid state electronic controls for HVACR’ pentice-Hall 1989.

WEB REFERENCES

1. http://gort.ucsd.edu/newjour/i/msg02859.html
2. http://www.brazeway.com/refrigeration
3. http://Progdev.sait.ab.ca/pwen220/119.ref-com.htm
4. http://147.46.94.112/journal/sej
5. http://www.iifiir.org

TH5103 – 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

EQUIPMENTS REQUIRED

1. Multi-cylinders Automotive Engine
2. CO/HC/Nox Analysers
3. Smoke meter
4. Variable Compression ratio petrol and diesel engines
5. Cooling tower test rig
6. Refrigeration cum Heat Pump test rig
7. Solar flat plate water heater test rig
8. Instruments for measuring solid / liquid / gas fuels properties
9. Solar Radiation measuring instruments
10. Non-IBR Boiler test rig
11. Heat exchanger test rig

TH5151 – 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

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”, Dhanapat Rai Publications, 1993
2. V. Ganesan, ‘Internal Combustion Engines”, Second Edition, TMH, 2002.
3. Duffy Smith, “Auto Fuel Systems”, The Good Heart Willox Company, Inc., 1987

IC5154 – INSTRUMENTATION FOR THERMAL SYSTEMS

L	T	P	C
3	0	0	3

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 intelligent instrument 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 intelligent instruments for the physical variables

UNIT IV FLOW VISUALISATION 8

Techniques – shadow graph – Schileren – interferometer – Laser Doppler anemometer – hear flux measurement – Telemetry in engines.

UNIT V MEASUREMENT ANALYSIS 10

Chemical, Thermal, magnetic and optical gas analysers – measurement of smoke, dust and moisture – gas chromatography – spectrometry – measurement pf, pH – Review of basic measurement techniques.

TOTAL: 45

REFERENCES

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

EY5152 – ENVIRONMENTAL ENGINEERING AND POLLUTION CONTROL

L	T	P	C
3	0	0	3

UNIT I INTRODUCTION 9

Global atmospheric change – Green house effect – Ozone Depletion – Natural Cycles – Mass and Energy Transfer – Material balance – Environmental chemistry and biology – Impacts – Environmental legislations.

UNIT II AIR POLLUTION 9

Pollutants – Sources and Effect – Air Pollution meteorology – Atmospheric dispersion – Indoor air quality – Control Methods and Equipments – Issues in Air Pollution control – Air sampling and measurement

UNIT III WATER POLLUTION 9

Water resources – Water Pollutants – Characteristics – Quality – Water Treatment systems – Wastewater 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 EIA test – Water Pollution from Tanneries and other Industries and their control – Environment Impact assessment for various projects – Case studies

Total: 45

TEXT BOOKS

1. G.Masters, “Introduction to Environmental Engineering and Science”, Prentice Hall of India Pvt Ltd, 2003.
2. H.S.Peavy, D.R..Rowe, G.Tchobanoglous, “Environmental Engineering”, McGraw-Hill BookCompany, 1985.

REFERENCE BOOKS

1 H.Ludwig, W.Evans, ‘Manual of Environmental Technology in Developing Countries”, International Book Company, Absecon Highlands, 1991

2. Arcadio P Sincero and G. A. Sincero, “Environmental Engineering – A Design Apporach”, Prentice Hall of India Pvt Ltd, 2002

TH5153 – SIMULATION LABORATORY

L	T	P	C
0	0	3	2

I Cycle

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

24

II Cycle

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

21

Total: 45

ELECTIVES

EY5051 – COGENERATION AND WASTE HEAT RECOVERY SYSTEMS

L	T	P	C
3	0	0	3

UNIT I INTRODUCTION 9

Introduction – Principles of Thermodynamics – Cycles – Topping – Bottoming – combined cycle – Organic Rankine Cycles – Performance indices of cogeneration systems – waste heat recovery – sources and types – Concept of trigeneration

UNIT II COGENERATION TEHNOLOGIES 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

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 and 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

TEXT BOOKS

1. Charles H.Butler, “Cogeneration”, McGraw Hill Book Co., 1984.
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. Sengupta Subrata, Lee SS EDS, “Waste Heat Utilization and Management”, Hemisphere, 1983.
3. De Nevers, Noel., “Air Pollution Control Engineering”, McGrawHill, 1995

EY5052 – ENERGY SYSTEMS MODELLING AND ANALYSIS

L	T	P	C
3	0	0	3

UNIT I INTRODUCTION 9

Primary energy analysis – Dead states and energy components – Energy balance for closed and control volume systems – applications of energy analysis for selected energy system design – Modelling overview – levels and steps in model development – examples of models – Curve fitting and regression analysis

UNIT II MODELLING AND SYSTEMS SIMULATION 9

Modelling of energy systems – Heat Exchanger – Solar collectors – Distillation – Rectifications – turbo machinery components – refrigeration systems – information flow diagram – solution of set of nonlinear algebraic equations – successive substitution – Newton Raphson – Examples of energy systems simulation

UNIT III OPTIMISATION 9

Objectives – constraints, problem formulation – Unconstrained problems – Necessary and Sufficiency conditions – Constrained Optimisation – lagrange multipliers – constrained variations – Linear Programming – Simplex tableau – pivoting – sensitivity analysis

UNIT IV ENERGY- ECONOMY MODELS 9

Multiplier Analysis – Energy and Environmental Input / Output Analysis – Energy Aggregation – Econometric Energy Demand Modeling – Overview of Econometric Methods – Dynamic programming – Search Techniques – Univariate / Multivariate.

UNIT V APPLICATIONS AND CASE STUDIES 9

Case studies of optimisation in Energy systems problems – Dealing with uncertainty – probabilistic techniques – Trade-offs between capital and energy using Pinch Analysis

Total: 45

TEXT BOOKS

1. W.F. Stoecker, “Design of Thermal Systems’, Mcgraw Hill, 1981
2. A.Bejan, G.Tsatsaronis and M.Moran, “Thermal Design and Optimization” John Wiley & Sons, 1996

REFERENCES

1. S.S.Rao, “Optimisation theory and applications”, Wiley Eastern, 1990
2. S.S. Sastry, “Introductory methods of numerical Analysis”, Prentice Hall, 1988
3. P. Meier, “Energy Systems Analysis for Developing Countries”, Springer Verlag,1984
4. R.de Neufville, “Applied Systems Analysis”, Mcgraw Hill, International Edition,1990
5. Beveridge and Schechter, “Optimisation Theory and Practice”, McGraw Hill, 1970

TH5051 – ADVANCED POWER PLANT ENGINEERING

L	T	P	C
3	0	0	3

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 – Radio activity – Fission process – reaction rates – diffusion theory, elastic scattering and slowing down – criticality calculations – critical heat flux – power reactors – nuclear safety – MHD & 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

REFERENCES

1. Haywood, R.W., “Analysis of Engineering Cycles”, Fourth Edition, Pergamon Press, 1991.
2. Wood, A.J., Wollenberg, B.F., “Power Generation, Operation & Control”, John Wiley, 1984.
3. Nag, P.K., “Power Plant Engineering”, Tata Mcgraw Hill Publishing Co Ltd, 1998.
4. Arora and Domkundwar, “A course in power Plant Engineering”, Dhanpat Rai & CO, 2004.
5. Gill, A.B., “Power Plant Performance”, Butterworths, 1984.
6. Lamarsh, J.R., “Introduction to Nuclear Engineering”, Second Edition, addison-Wesley, 1983.

IC5052 – 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

REFERENCES

1. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, 1995.
2. Ghoshdasdidar, P.S., "Computer Simulation of flow and heat transfer" Tata McGraw-Hill Publishing Company Ltd., 1998.
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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.

EY5101 – RENEWABLE ENERGY SYSTEMS

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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

TEXT BOOKS

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

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

RA5153 – CRYOGENIC ENGINEERING

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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

REFERENCES

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

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2. www.cryogenicsociety.org/
3. www.iifiir.org/
4. www.linde.com
5. www.airliquide.com/
6. www.cern.ch
7. www.nist.gov

RA5052 – REFRIGERATION MACHINERY AND COMPONENTS

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UNIT I REFRIGERANT COMPRESSORS 9

Hermetic compressors – Reciprocating, Rotary, Scroll Compressors and Open type compressors – Reciprocating, Centrifugal and 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 and Calorimetric.

Total: 45

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 Air-conditioning” Good Heart - Wilcox Co. Inc., 1985.
4. Cooper &Williams, B. “Commercial, Industrial, Institutional Refrigeration, Design, Installation and Trouble Shooting” Eagle Wood Cliffs (NT) Prentice Hall, 1989.
5. http://www.chensources.com/ctowers22.shtml
6. http://www.fortunecity.com/campus/german/201/ctowers.html

RA5011 – FOOD PROCESSING, PRESERVATION AND TRANSPORT

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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 and Vegetables

UNIT III FREEZING & DRYING **12**

Precooling, Freeze drying principles, Cold storage and 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 and instrumentation – Fire protection – Inspection and maintenance

UNIT V TRANSPORT **5**

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

Total: 45

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”, Third Edition. AVI Pub. Company Inc. 1989.
4. Clive V. I. Dellino, “Cold and Chilled Storage Technology”, Van Nostrand Reinhold Pub. 1991
5. Arora C.P., “Refrigeration and Air conditioning”, Second Edition. McGraw-Hill, Publication, 2000.
6. ASHRAE Handbook, Refrigeration, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. Atlanta, 1988.

TH5053 – INDUSTRIAL REFRIGERATION SYSTEMS

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UNIT 1 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 – adventage 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

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1. Wilbert F.Stoecker, “Industrial Refrigeration Hand Book”, McGraw-Hill, 1998.
2. ASHRAE Hand Book: Fundamentals, 1997.
3. ASHRAE Hand Book: Refrigeration, 1998.
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3. http://www.aquasystemsinsc.com/metric_files.html
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RA5053 – FANS, BLOWERS AND COMPRESSORS

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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 – cross-flow 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

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2. Stepanoff A.J., “Turbo-blowers”, John Wiley & Sons, 1970.
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