NOORUL ISLAM CENTRE FOR HIGHER EDUCATION

NOORUL ISLAM UNIVERSITY, KUMARACOIL

M.E. THERMAL ENGINEERING

SEMESTER I

CURRICULUM & SYLLABUS

THEORY						
S.No.	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**
1.	MA1503	Applied Mathematics	3	1	0	4
2.	TE1501	Advanced Fluid Mechanics	3	0	0	3
3.	TE1502	Advanced Thermodynamics	3	0	0	3
4.	TE1503	Instrumentation and control for thermal system.	3	0	0	3
5.	TE1504	Performance Assessment of Mechanical Equipments	3	0	0	3
6.	XX15E1	Elective - I	3	0	0	3
PRACTICAL						
7.	TE1571	Thermal Engineering Lab -I	0	0	4	2
TOTAL			**18**	**1**	**4**	**21**

MA1503 APPLIED MATHEMATICS 3 1 0 4

AIM:

To equip the students of Engineering, the knowledge of Mathematics and its applications so as to enable them to apply them for the branch in which they are admitted.

OBJECTIVE:

To impart the basic knowledge about Matrices, Transforms, Conformal Mappings and Numerical problems so that those concepts could be adopted in their concerned branch.

UNIT I ADVANCED MATRIX THEORY 9

Generalised Eigen vectors– Jordan canonical form — Matrix norms – Singular value decomposition – Pseudo inverse – Least square approximations – QR decomposition.

UNIT II CALCULUS OF VARIATIONS 9

Euler's equation – Functional dependent on first and higher order derivatives – Functional dependent on functions of several independent variables —Isoperimetric Problems.

UNIT III SIMULATION 9

Discrete Event Simulation – Stochastic Simulation - Monte Carlo Simulation – Generation of Random Numbers using Congruent method – Applications to Queueing systems.

UNIT IV CONFORMAL MAPPING AND ELLIPTIC INTEGRAL 9

Schwarz – Christoffel Transformation – Transformation of boundaries in parametric form – Physical applications – Application to Fluid flow.

UNIT V FIRST AND SECOND ORDER ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS 9

Solution of first order differential equations -Single step Methods: Taylor's Series, Fourth order Runge-Kutta method. Finite difference solution of one dimensional heat equation: Bender Schmidt Method– One dimensional wave equation and two dimensional Poisson equations.

L: 45 + T: 15, TOTAL: 60 PERIODS

REFERENCES:

1. Bronson, R., "Matrix Operations", Schaum's Outline Series, McGraw–Hill, New York
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.
3. Gupta, A.S., "Calculus of Variations with Applications", Prentice-Hall of India, New Delhi.
4. Dr.Venkataraman, M.K., " Higher Mathematics for Engineering and Science", National Publishing Company.
5. Philips and Raveendran " Operations Research- Principles and Practice"
6. Jain M.K., Iyengar. S.R.K and Jain. R.K, "Numerical method for scientific and Engineering Computations", New Age International(P) Ltd., Publishers, 2003.
7. Grewal B.S., "Higher Engineering Mathematics"- 40th Edition, Khanna Publishers, Delhi 2007.

TE1501 ADVANCED FLUID MECHANICS 3 0 0 3

OBJECTIVE:

This course is intended to consolidate your knowledge of fluid mechanics and to develop a critical and mature approach to the subject. It will supply the background preparation for more specialized courses on fluid mechanics.

UNIT I GOVERNING EQUATIONS & POTENTIAL FLOW 9

Reynolds transport theorem, Integral and differential forms of governing equations: mass, momentum and energy conservation equations, Navier-Stokes equations, Euler's equation, Bernoulli's Equation.

Revisit of **fluid** kinematics, Stream and Velocity potential function, Circulation, Irrotational vortex, Basic plane potential flows: Uniform stream; Source and Sink; Vortex flow, Doublet, Superposition of basic plane potential flows, Flow past a circular cylinder, Magnus effect; Kutta-Joukowski lift theorem; Concept of lift and drag.

UNIT II AND LAMINAR BOUNDARY LAYER 9

Boundary layer equations, Boundary layer thickness, Boundary layer on a flat plate, similarity solutions, Integral form of boundary layer equations, Approximate Methods, Flow separation, Entry flow into a duct.

UNIT III-TURBULENT FLOW 9

Introduction, Fluctuations and time-averaging, General equations of turbulent flow, Turbulent boundary layer equation, Flat plate turbulent boundary layer, Turbulent pipe flow, Prandtl mixing hypothesis, Turbulence modeling, Free turbulent flows.

UNIT IV - COMPRESSIBLE FLOWS 9

Speed of sound and Mach number, Basic equations for one dimensional flows, Isentropic relations, Normal-shock wave, Rankine-Hugoniot relations, Fanno and Rayleigh curve, Mach waves, Oblique shock wave, Prandtl-Meyer expansion waves, Quasi-one dimensional flows, Compressible viscous flows, Compressible boundary layers.

UNIT V INTRODUCTION TO CFD 9

Boundary conditions, Basic discretization – Finite difference method, Finite volume method and Finite element method.

TOTAL: 45 PERIODS

REFERENCES

1. Currie, LG., Fundamental Mechanics of Fluids, 3rd ed., CRC Press, 2002.
2. White, P.M., Viscous Fluid Flow, 2nd ed., McGraw-Hill, 1991.
3. Ockendon, H. and Ockendon, J., Viscous Flow, Cambridge Uni. Press,1995.
4. Shapiro A F The Dynamics of Compressible flow Vd 1, The Ronald Press company 1963
5. Shames, Mechanics of Fluids, MC grow Hill 1962 Book company 1962
6. Schlichting H Boundary layer theory MC Grow Hill Book company 1979
7. Hoffmann, K.A. and Chiang, S.T., Computational Fluid Dynamics for Engineers, Engineering Education Systems, 2000.

TE1502 ADVANCED THERMODYNAMICS 3 0 0 3

(Use of approved charts permitted)

OBJECTIVES

- To Analyse the equilibrium and kinetics of combustion of different fuels
- To Apply the fundamental principles of thermodynamics to numerous engineering devices
- To use a systems approach to simplify a complex problem

1. AVAILABILITY ANALYSIS AND THERMODYNAMIC PROPERTY RELATIONS 9

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 Cp and CV Clausius Clayperon equation, Joule – Thomson coefficient. Bridgeman tables for thermodynamic relations.

2.MULTI COMPONENT SYSTEMS 9

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.

3. CHEMICAL THERMODYNAMICS AND EQUILIBRIUM 9

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. Equilibrium constant for gaseous mixtures - evaluation of equilibrium composition.

4. STATISTICAL THERMODYNAMICS 9

Statistical thermodynamics- introduction, energy states and energy levels, macro and microscales, thermodynamic probability, Ideal Monatomic gas, Partition function, Calculation of the translational properties of an ideal monatomic gas, Sector - Tetrode equation, Potential energy function for a diatomic molecule, Rigid rotor harmonic – oscillator approximation, Rotational and vibrational partition functions of ideal polyatomic gases.

5. THERMODYNAMIC OF IRREVERSIBLE PROCESSES 9

Irrevesible processes, Phenomenological laws, Application of onsager - reciprocal relations, Seebeek effect, Peltier effect, Thompson effect. Conjugate fluxes and forces - entropy production ,thermo – electric phenomena, formulations.

TOTAL: 45 PERIODS

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 Ediction, McGraw-Hill Inc., 1998.

4. Smith, J.M and Van Ness., H.C., Introduction to chemical Engineering Thermodynamics, Fourth Edition, McGraw-Hill Inc., 1987.
5. Sonntag, R.E., and Vann Wylen, G, Introduction to Thermodynamics, Classical and Statistical, third Edition, John Wiley and Sons, 1991.
6. Sears, F.W. and Salinger G.I., Thermodynamics, Kinetic Theory and Statistical Thermodynamics, third Edition, Narosa Publishing House, New Delhi, 1993.
7. DeHoft, R.T. Thermodynamics in Materials Science, McGraw-Hill Inc., 1993.
8. Rao, Y.V.C., Postulational and Statistical thermodynamics, Allied Publisher Limited, New Delhi, 1994.

TE1503 INSTRUMENTATION FOR THERMAL SYSTEMS 3 0 0 3

PURPOSE

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

1. MEASUREMENT SYSTEM 9

Concept of generalized measurement system – system configurations - Errors Problem analyses - Basic characteristics of measuring devices – Calibration – introduction to data acquisition and processing systems – compact data loggers

2. TEMPERATURE & PRESSURE MEASUREMENT 9

Temperature – thermo electric sensors – Thermocouple & electrical resistance- Radiation & optical thermometers – Quartz crystal Thermometers – High speed Temperature probe.
Pressure :Variable reluctance & LVDT Type pressure sensors – Knudsen gauge – Thermal conductivity ionization gauge High pressure measurement – Piezo-electric and vibrating elements pressure sensors.

3. FLOW VISUALISATION 9

Flow: Electromagnetic flow meter – Smoke tube and laser Doppler anemometer - ultrasonic flow meter – Rotor Torque mass flow meter – Flow visualization Techniques – shadow graph – Schilierene Apparatus. Measurement of speed, vibration, humidity, heat flux and time

4. MEASUREMENT ANALYSIS 6

Gas analysis – Measurement of CO_2, N O_2,CO, hydrocarbon and S O_2– use of chromatography – smoke Measurement. NOX and particulate measurement – Concentration measurement.

5. CONTROL SYSTEMS 12

Control Systems, Types, block diagrams and performance analysis, signal flow graphs, Hydraulic, Pneumatic and electronic controllers, Transient and steady state response; time domain and Laplace transform representation of P, P + D & P + I control action;frequency response analysis and stability of control systems; applications, ProgrammableLogical Controllers-programming, applications.

TOTAL: 45 PERIODS

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, New Delhi, 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.
7. Nakra B.C. "Theory and Applications of Automatic Controls", New Age International (P) Ltd.,New Delhi.

TE1504 PERFORMANCE ASSESSMENT OF MECHANICAL EQUIPMENTS 3 0 0 3

OBJECTIVE:

UNIT-I BOILERS 9

Introduction, types, combustion in boilers, performances evaluation, analysis of losses, feed water treatment, blow down, energy conservation opportunities, Performance terms and definitions, reference standards, direct and indirect method testing, boiler efficiency calculation, factors affecting boiler performance, modern trends.

UNIT-II FURNACES AND COGENERATION 9

FURNACES

Classification, types of fuels, general fuel economy measures in furnaces, excess air, heat distribution, temperature control, draft control, waste heat recovery, performance terms and definitions, furnace efficiency, testing method.

COGENERATION

Definition, need, application, advantages, classification, energy saving, performance terms and definitions, field testing procedure, diesel generating system-factors affecting selection, energy performance assessment of diesel conservation avenues, trends in different cogeneration **power** plants.

UNIT-III - FANS AND BLOWERS 9

Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities, performance terms and definitions, field testing

UNIT-IV - PUMPING SYSTEM AND COMPRESSED AIR SYSTEM 9

Types, pumping system components, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities, performance terms and definitions, field testing

Types of air compressors, compressor efficiency, efficient compressor operation,

Compressed air system components, capacity assessment, and leakage test, factors affecting the performance and savings opportunities.

UNIT-V -ENERGY CONSERVATION: 9

Energy conservation in, boilers, furnaces, pumps, fans, pumping systems, compressed air systems, Waste heat recovery: recuperators, heat wheels, heat pipes, heat pumps.

TOTAL: 45 PERIODS

REFERENCES

1. Handbook on Energy Audit and Environment Management, Abbi Y.A, Jain, Shashank TERI Press New Delhi,2006
2. Energy Management Handbook, Wayne C Turner, The Fairmont Press Inc.
3. Boiler Operator's Guide Fourth Edition, Anthony L Kohan, McGraw Hill.
4. Boiler Test Calculations – J. Senior, Edward Arnold Publisher.
5. Gas Turbine Engineering Handbook, Meherwan P Boyce, Gulf Publishing Company.
6. Modeling of Gas Fired Furnaces & Boilers, Rhine J M
7. Pumps, Principles and Practice, Jaico Publishing House, Mumbai.
8. Reciprocating Compressors Operation and Maintenance, Heinz P Bloch & John J
9. Principles and Performance in Diesel Engineering, Sam Haddad and Neil Watson,

TE1571 THERMAL ENGINEERING LAB - I 0 1 2 2

1) Determination of efficiency of boiler
2) Study of heat exchangers.
3) Study of variable speed drives
4) COP of cooling towers.
6) Study of diesel generator set.
7) Measurement of load and power factor for the electrical utilities.
8) Determination of efficiency of pumping system.
9) Performance evaluation of blower
10) Performance evaluation of air compressors
11) Study of solar collector.
12) Flue gas analysis of petrol, diesel and LPG Engines.
13) Performance trial on 4-cylinder 4-stroke petrol engine

TOTAL: 45 PERIODS

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M.E. THERMAL ENGINEERING

SEMESTER II

CURRICULUM & SYLLABUS

THEORY					
Course Code	**Course Title**	**L**	**T**	**P**	**C**
TE1505	Design of Heat Exchangers	3	0	0	3
TE1506	Advanced Heat and mass Transfer	3	0	0	3
TE1507	Heating Ventilation air conditioning (HVAC).	3	0	0	3
TE1508	Fuels and Combustion	3	0	0	3
TE1509	Energy Systems Modeling and Analysis	3	0	0	3
XX15E2	Elective II	3	0	0	3
PRACTICAL					
TE1572	Thermal Engineering Lab -II	0	0	4	2
TOTAL		18	0	4	20

TE1505 DESIGN OF HEAT EXCHANGERS 3 0 0 3

UNIT-I CONSTRUCTIONAL DETAILS AND HEAT TRANSFER: 9

Types - Shell and Tube Heat Exchangers - Regenerators and Recuperators - Industrial Applications Temperature Distribution and its Implications - LMTD - Effectiveness – NTU method.

UNIT-II FLOW DISTRIBUTION AND STRESS ANALYSIS: **9**

Effect of Turbulence - Friction Factor - Pressure Loss - Channel Divergence Stresses in Tubes - Heater 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 Typical Liquid - Gas-Gas-Liquid Heat Exchangers , Design of Surface and Evaporative Condensers - Shell and Tube Heat Exchangers – Kern Method – Bell Delware method -- The stream analysis method

UNIT-IV RECENT DEVELOPMENTS IN HEAT EXCHANGERS 9

Codes of mechanical design of heat exchanger, Network of Heat exchangers, Computerized methods for design and analysis of Heat Exchangers, Power plant heat exchanger, heat exchanger for heat recovery at low,medium and high temperatures

UNIT-V COOLING TOWERS: 9

Types – counter flow – cross flow - Packings - Spray Design - Selection of Pumps - Fans and Pipes - Testing and Maintenance - Experimental Methods – Types of draft – natural and forced.

TOTAL: 45 PERIODS

REFERENCES:

1. T. Taborek, G.F. Hewitt and N.Afgan, Heat Exchangers, Theory and Practice, McGraw Hill Book
Company, 1980
2. Walker, Industrial Heat Exchangers - A Basic Guide, McGraw Hill Book Co., 1980
3. Nicholas Cheremisioff, Cooling Tower, Ann Arbor Science Pub 1981
4. Arthur P.Fraas, Heat Exchanger Design, John Wiley & Sons, 1988
5. Kern D.Q., Process Heat transfer, Tata McGraw -Hill, New Delhi, 1999.

TE1506 ADVANCED HEAT TRANSFER 3 0 0 3

(Use of approved handbook permitted)

1. CONDUCTION AND RADIATION HEAT TRANSFER 9

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.

2. TURBULENT FORCED CONVECTIVE HEAT TRANSFER 9

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.

3. PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGER 9

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

4. 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.

5. MASS TRANSFER AND ENGINE HEAT TRANSFER CORRELATION 9

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

TOTAL: 45 PERIODS

REFERENCES

1. Incropera F.P. and DeWitt. 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, Gersten, Boundarylayer 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, NY1985
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

TE1507 HEATING VENTILATION AIR CONDITIONING 3 0 0 3

OBJECTIVE

Have the students understand the application of basic thermodynamics, fluid mechanics and heat transfer in sizing HVAC systems and estimating their operating costs, and have the students perform HVAC load and energy calculation procedures that are consistent with current accepted industry standards, and familiarize the students with many of the system types and the various aspects of engineering design of HVAC systems used for acceptable environmental conditions in buildings, and have the students be capable of presenting to their peers the results of an independent study in a particular area of HVAC systems.

UNIT I: ELECTRICAL CONTROLS FOR HVAC 6

Installation of Heating, Cooling and Refrigeration Systems , Basic Electric Motors, Electronic Control Devices, Residential Air-Conditioning Control Systems

UNIT: II AIR DISTRIBUTION SYSTEMS **7**

Diffuser Design and Selection, Diffuser Design and Selection, Diffuser, Operational Principles, Zone Location, Selection Criteria; Device Selection, Fan (Air Pump) Selection, System, Effects on Performance, Field Testing, Fan Output Controls and Energy Utilization; Pressure Loss in Ducts and Fittings, Duct System Design; Equal Friction Method; Comparison of Different Design Solutions, Energy Simulations

UNIT: III HYDRONIC SYSTEMS **8**

Flow Regimes, HVAC Systems; Conservation of Energy Applied to Flows, System Characteristic Constants; Flow Measurements - Velocity Profiles; Total Flow, Centrifugal Pumps, Operating Characteristics, Selection, Pipe System Fundamentals, Fitting Coefficients & Equivalent Length Estimations of ΔP-system; Effects of Dissolved Gases on Hydronic System Performance; Temperature Induced Expansion Effects, 2-way & 3-way Valves; Common Pipe; Commercial Systems, Steam System Design

UNIT: IV INTRODUCTION TO HEATING FUNDAMENTALS & HEAT LOSS AND HEAT GAIN CALCULATIONS **12**

Types of automatic controls, Space temperature controls, Pressure controls, Introduction to motor control device, Portable electric heating devices, Sequencers, electric duct heater, Gun-type oil burners, Fuel oil pumps, Ventilation, Air Cleaning, Duct cleaning, Humidification, Heating Load , Wall Moisture, Introduction of Design Problem , Cooling Principles / Solar, Residential Cooling Loads /

UNIT: V ADVANCED REFRIGERATION **12**

Compression Cycles, Environmental Chemistry of Refrigerants - Global Warming; Ozone Depletion; Potential Environmental Impacts of Refrigerants ; Absorption Cooling, Principles of Operation; Cycle Analysis; COP Comparison to Refrigeration Cycle; Binary Mixtures and their Refrigeration processes, LiBr, NH3 System Differences; Utilization in Combined, Heat and Power Systems

TOTAL: 45 PERIODS

TEXT BOOKS

1. F.C. McQuiston, J.D. Parker, and J.D. Spitler, 2005. Heating, Ventilating and Air-Conditioning – Analysis and Design, Sixth Edition, John Wiley & Sons, Inc
2. Principles of Heating, Ventilating and Air Conditioning. Ronald Howell, Harry Sauer and William Coad. 1998. American Society of Heating, Refrigerating and Air-Conditioning Engineers. Atlanta. http://www.ashrae.org/
3. ASHRAE Handbook – Fundamentals. ASHRAE

TE1508 FUELS & COMBUSTION 3 0 0 3

1. CHARACTERIZATION **9**

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.

2. SOLID FUELS & LIQUID FUELS 9

(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.

3. GASEOUS FUELS 9

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.

4. COMBUSTION: STOICHIOMETRY & KINETICS 9

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.

5. COMBUSTION EQUIPMENTS 9

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

REFERENCES

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

TE1509 ENERGY SYSTEMS MODELING AND ANALYSIS 3 0 0 3

UNIT I - MODELS AND MODELING APPROACHES 9

Macroeconomic Concepts - Measurement of National Output - Investment Planning and Pricing - Economics of Energy Sources - Reserves and Cost Estimation.

UNIT II - INPUT OUTPUT ANALYSIS 9

Multiplier Analysis - Energy and Environmental Input / Output Analysis - Energy Aggregation –Econometric Energy Demand Modeling - Overview of Econometric Methods.

UNIT III - ENERGY DEMAND ANALYSIS AND FORECASTING 9

Methodology of Energy Demand Analysis - Methodology for Energy Technology Forecasting -Methodology for Energy Forecasting - Sectoral Energy Demand Forecasting.

UNIT IV - ECONOMICS OF STANDALONE POWER SUPPLY SYSTEMS 9

Solar Energy - Biomass Energy - Wind Energy and other Renewable Sources of Energy - Economics of Waste Heat Recovery and Cogeneration - Energy Conservation Economics.

UNIT V -: PROJECT MANAGEMENT-FINANCIAL ACCOUNTING 9

Cost Analysis - Budgetary Control - Financial Management - Techniques for Project Evaluation.

TOTAL: 45 PERIODS

REFERENCE BOOKS

1. M.Munasinghe and P.Meier (1993): Energy Policy Analysis and Modeling, Cambridge University Press.
2. W.A.Donnelly (1987): The Econometrics of Energy Demand: A Survey of Applications, New York.
3. S.Pindyck and Daniel L.Rubinfeld (1990): Econometrics Models and Economic Forecasts, 3rd edition MC Graw -Hill, New York.
4. UN-ESCAP (1991): Sectoral Energy Demand Studies: Application of the END-USE Approach to
Asian Countries, New York.
5. UN-ESCAP (1996): Guide Book on Energy -Environment Planning in Developing Countries: Methodological Guide on Economic Sustainability and Environmental Betterment ThroughEnergy Savings and Fuel Switching in Developing Countries, New York.
6. S.Makridakis , Wiley(1983): Forecasting Methods and Applications.

TE1572 THERMAL ENGINEERING LAB -II 0 1 2 2

1. Flow past an aerofoil: Pressure measurements.
2. Numerical Simulation ofFlow through a converging-diverging nozzle: subsonic and supersonic flows
3. Friction factor determination: incompressible flow through pipes/ducts
4. Visit report on (Any Two) (a) Cold Storage,(b) Ice Plant,(c) Dairy,(d) Pharmaceutical
5. Laminar/Turbulent boundary layer over a flat plate.
6. Steady State Conduction in Solid
7. Steady State Convection in Solid
8. Steady State Radiation in Solid

9. Steady state conduction in Fluids
10. Steady state convection in Fluids
11. Energy system simulations

TOTAL: 45 PERIODS

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M.E. THERMAL ENGINEERING

CURRICULUM & SYLLABUS

SEMESTER III

S.No.	Course Code	Course Title	L	T	P	C
THEORY						
1.	XX15E3	Elective III	3	0	0	3
2.	XX15E4	Elective IV	3	0	0	3
3.	XX15E5	Elective V	3	0	0	3
PRACTICAL						
4.	TE15P1	Industry Internship Training	0	0	4	2
5.	TE15P2	Project work – Phase I	0	0	18	6
TOTAL			9	0	22	17

TE15P1 INDUSTRIAL INTENSHIP TRAINING

The objective of the training is an aiding for the students of M.E. Thermal Engineering interms of Industrial Exposer.

- Know the real life problem of any industry
- Understand the importance of team work, cross culture, regulations and disciplines of industries.
- Prepare himself for meeting the requirements of industries
- The scope of this training is to undergo intensive implant training for atleast 15 days in any of the process industries, study the processes, and operations submit the report of the training with the information about the product, process and the identified problems, along with the certificate and present before the review committee

Outcome

- The students will have reallife industrial problems for the projectwork
- The student will know the state of the art of the technology of industries
- The student will understand the environment change/adopt this alternates & culture towards industrial practice.

Duration: 2- 3 weeks

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M.E. THERMAL ENGINEERING

CURRICULUM & SYLLABUS

SEMESTER IV

S.No.	Course Code	Course Title	L	T	P	C
1.	TE15P5	Project work – Phase II	0	0	36	18
TOTAL			0	0	36	18

NOORUL ISLAM UNIVERSITY, KUMARACOIL

M.E. THERMAL ENGINEERING

CURRICULUM & SYLLABUS

LIST OF ELECTIVES

Sl.No	COURSE CODE	COURSE NAME	L	T	P	C
1	TE15A1	Renewable Energy Systems	3	0	0	3
2	TE15A2	Cogeneration and Waste Heat Recovery Systems	3	0	0	3
3	TE15A3	Fans, Blowers and Compressors	3	0	0	3
4	TE15A4	Environmental Pollution and Abatement	3	0	0	3
5	TE15A6	Computational Fluid Dynamics	3	0	0	3
6	TE15A7	Cold Chain Technology	3	0	0	3
7	TE15A8	Cryogenic Engineering	3	0	0	3
8	TE15A9	Air Conditioning System Design	3	0	0	3
9	TE15B1	Advanced Internal Combustion Engineering	3	0	0	3
10	TE15B2	Transport Phenomena	3	0	0	3
11	TE15B3	Technology Management	3	0	0	3
12	TE15B4	Fluidized Bed Systems	3	0	0	3
13	TE15B5	Advanced Finite Element Analysis	3	0	0	3
14	TE15B6	Jet Propulsion And Rocketry	3	0	0	3

TE15A1 RENEWABLE ENERGY SYSTEMS 3 0 0 3

UNIT- I: ENERGY SCENARIO 9

Energy Scenario: Classification of Energy Sources, Energy resources (Conventional and non conventional), Energy needs of India, and energy consumption patterns. Worldwide Potentials of these sources. Energy efficiency and energy security. Energy and its environmental impacts. Global environmental concern, Kyoto Protocol, Concept of Clean Development Mechanism (CDM) and Prototype Carbon Funds (PCF). Factors favoring and against renewable energy sources,IRP

UNIT II - SOLARENERGY 9

Solar thermal Systems: Types of collectors, Collection systems, efficiency calculations, applications. Photo voltaic (PV) technology: Present status, - solar cells , cell technologies, characteristics of PV systems, equivalent circuit, array design , building integrated PV system, its components , sizing and economics. Peak power operation.Standalone and grid interactive systems.

UNIT III – WIND ENERGY 9

Wind Energy : wind speed and power relation, power extracted from wind, wind distribution and wind speed predictions.Wind power systems: system components, Types of Turbine, Turbine rating Choice of generators, turbine rating, electrical load matching, Variable speed operation, maximum power operation, control systems, system design features, stand alone and grid connected operation.

UNIT IV – OTHER ENERGY SOURCES 9

Biomass – various resources, energy contents, technological advancements, conversion of biomass in other form of energy – solid, liquid and gases. Gasifiers, Biomass fired boilers, Cofiring, Generation from municipal solid waste, Issues in harnessing these sources. Hydro energy – feasibility of small, mini and micro hydel plants scheme layout economics. Tidal and wave energy ,Geothermal and Ocean-thermal energy conversion (OTEC) systems – schemes, feasibility and viability.

UNIT V - ENERGY STORAGE AND GRID SYSTEMS 9

Energy storage: Battery – types, equivalent circuit, performance characteristics, battery design, charging and charge regulators. Battery management. Fly wheelenergy relations, components, benefits over battery. Fuel Cell energy storage systems. Ultra Capacitors. Stand alone systems, Hybrid systems – hybrid with diesel, with fuel cell, solarwind, wind –hydro systems, mode controller, load sharing, system sizing. Hybrid system economics. Grid integration with the system: Interface requirements, Stable operation, Transient-safety, Operating limits of voltage, frequency, stability margin, energy storage, and load scheduling. Effect on power quality - harmonic distortion, voltage transients and sags, voltage flickers. Dynamic reactive power support. Systems stiffness.

TOTAL: 45 PERIODS

REFERENCE BOOKS

1. Renewable energy technologies - R. Ramesh, Narosa Publication.
2. Energy Technology – S. Rao, Parulkar
3. Non-conventional Energy Systems – Mittal, Wheelers Publication.
4. Wind and solar systems by Mukund Patel, CRC Press.
5. Solar Photovoltaics for terrestrials , Tapan Bhattacharya.

6. Wind Energy Technology – Njenkins, John Wiley & Sons,
7. Solar & Wind energy Technologies – McNeils, Frenkel, Desai, Wiley Eastern.
8. Solar Energy – S.P. Sukhatme, Tata McGraw Hill.
9. Solar Energy – S. Bandopadhay, Universal Publishing.
10. Guide book for National Certification Examination for EM/EA – Book 1

TE15A2 COGENERATION AND WASTE HEAT RECOVERY SYSTEMS

3 0 0 3

UNIT I: COGENERATION 9

Definition, need, application, advantages, classification, energy saving, performance terms and definitions, field testing procedure, diesel generating system-factors affecting selection, energy performance assessment of diesel conservation avenues, trends in different Cogeneration power plants.

UNIT II: APPLICATION & TECHNO ECONOMICS OF COGENERATION 9

Cogeneration Application in various industries like Cement, Sugar Mill, Paper Mill etc. Sizing of waste heat boilers - Performance calculations, Part load characteristics selection of Cogeneration Technologies – Financial considerations - Operating and Investments - Costs of Cogeneration.

UNIT III: ISSUES IN COGENERATION 9

Cogeneration plants electrical interconnection issues – utility and 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 9

Introduction - Principles of Thermodynamics and Second Law - sources of Waste Heat recovery - Diesel engines and Power Plant etc. 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 ENVIRONMENTAL CONSIDERATIONS 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.

TOTAL: 45 PERIODS

REFERENCE BOOKS

1. Charles H.Butler, Cogeneration, McGraw Hill Book Co., 1984.
2. Horlock JH, Cogeneration - Heat and Power, Thermodynamics and Economics, Oxford,1987.
3. Institute of Fuel, London, Waste Heat Recovery, Chapman & Hall Publishers, London, 1963.
4. Sengupta Subrata, Lee SS EDS, Waste Heat Utilization and Management, Hemisphere, Washington, 1983.
5. De Nevers, Noel., Air Polllution Control Engineering, McGrawHill, New York,1995.

WEBSITES:
1. http ://www.sicom.nl
2. http ://www.jenbacher.com
3. www.cogen.com

TE15A3 FANS, BLOWERS AND COMPRESSORS 3 0 0 3

UNIT I - PRINCIPLES OF TURBOMACHINERY: 9

The turbo machine, Positive displacement machines and turbo machines, Static and stagnation states Application of first and second laws to turbo machines, Efficiency of turbo machines. The Euler turbine equation, Fluid energy changes, Impulse and reaction, Turbines-utilization factor, Compressors and pumps

UNIT II - STEAM AND GAS TURBINES: 9

Back pressure, pass-out and mixed-pressure turbines, topping turbine, steam accumulator, special considerations in design of nuclear steam turbines .Impulse staging, Velocity and pressure compounding, Effects of blade and nozzle losses, Reaction staging, Reheat factor in turbines, Problem of radial equilibrium, Performance characteristics of steam turbines**.** Governing of turbines, part load operation, pressure distribution at part load, mechanisms of governing, integrated control of thermal power plant.

UNIT III - FANS and BLOWERS: 9

Introduction, Centrifugal blower, Types of vane shape, Size and speed of machine, Vane shape and efficiency, Vane shape and stresses, Vane shape and characteristics, Actual performance characteristics, The slip coefficient, Fan laws ,characteristics and Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities

UNIT IV - RECIPROCATING COMPRESSORS: **9**

Constructional details – open , hermetic and semi-sealed compressors, Performance of the ideal compressor , Clearance volumetric efficiency Effects of evaporator and condenser pressures, Actual volumetric efficiency, Effects of cylinder cooling, heating and friction, Empircial equations for actual volumetric efficiency, Power requirements of ideal and actual compressors, optimum work for given condenser and evaporator pressures, mean effective pressure, pull down characteristics , Compressor discharge temperatures and need for cooling and Capacity control

UNIT V - CENTRIFUGAL COMPRESSORS: **9**

Low-speed steam engine driven compressors, High-speed electric motor driven compressors, Rotary- single vane and multi-vane compressor, Centrifugal compressors, Velocity diagrams, Efficiency considerations, Construction details, applications and performance characteristics, Screw compressors, Basic principles- single screw and double screw compressors. Working principle, work requirement and performance characteristics, Comparison with reciprocating and centrifugal compressors and Scroll compressors

TOTAL: 45 PERIODS

REFERENCE BOOKS

1) The Design of High Efficiency Turbomachinery and Gas Turbines, Wilson and Korakianitis, Prentice Hall, 1998.

2) Turbomachinery: Basic Theory and Applications, E. Logan, Marcel Dekker, 1993.
3) Principles of Turbomachinery, Shepherd, MacMillian, 1989.
4) Gas Turbine Theory, Cohen, et al., John Wiley & Sons, 1991.
5) Handbook of Turbomachinery, Edited by E. Logan and R. Roy, Marcel Dekker, 2003.
6) Pump Characteristics and Applications, M.W. Volk, Marcel Dekker, 1996.
7) Principles of Turbomachinery in Air-Breathing Engines, Baskharone, Cambridge, 2006.

TE15A4 ENVIRONMENTAL POLLUTION AND ABATEMENT 3 0 0 3

1. 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. Classification and sources of pollutants-CO, CO2, O2, N2 cycles – sources and sink.

2. AIR POLLUTION & POLLUTANT MEASUREMENT METHODS- 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 and emission standards

3. WATER POLLUTION 9

Water resources - Water Pollutants - Characteristics – Quality - Water Treatment systems – Wastewater treatment - Treatment, Utilization and Disposal of Sludge - Monitoring compliance with Standards

4. WASTE MANAGEMENT & REACTIONS OF POLLUTANTS IN THE ATMOSPHERE WASTE MANAGEMENT 9

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

Smoke, smog, fog, acid rain and ozone layer. Global warming and its effects. Regulatory laws and standards. Atmospheric diffusion of pollutants, transport, transformation and deposition. Atmospheric lapse rate, inversions and heat balance.

UNIT V CONTROL PRINCIPLES- 9

Removal of gaseous pollutants by absorption, adsorption, chemical reaction and other methods. Selective catalytic reduction of NOX. Particulate emission control; settling chambers, cyclone separation, wet collectors, fabric filters and electrostatic precipitators. Clean coal technology and shifted emphasis on non-carbon sources of energy.

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 Enginering - McGraw- Hill BookCompany, NewYork.

REFERENCE BOOKS

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 Apporach, Prentice Hall of India Pvt Ltd, New Delhi.

TE15A6 COMPUTATIONAL FLUID DYNAMICS 3 0 0 3

UNIT - I

INTRODUCTION: Finite difference method, finite volume method, finite element method, governing equations and boundary conditions, Derivation of finite difference equations. Solution methods: Solution methods of elliptical equations — finite difference formulations, interactive solution methods, direct method with Gaussian elimination. Parabolic equations-explicit schemes and Von Neumann stability analysis, implicit schemes, alternating direction implicit schemes, approximate factorization, fractional step methods, direct method with tridiagonal matrix algorithm.

UNIT – II

Hyperbolic equations: explicit schemes and Von Neumann stability analysis, implicit schemes, multi step methods, nonlinear problems, second order one-dimensional wave equations. Burgers equations: Explicit and implicit schemes, Runge-Kutta method.

UNIT - III

FORMULATIONS OF INCOMPRESSIBLE VISCOUS FLOWS: Formulations of incompressible viscous flows by finite difference methods, pressure correction methods, vortex methods. Treatment of compressible flows: potential equation, Euler equations, Navier-stokes system of equations, flow field-dependent variation methods, boundary conditions, example problems.

UNIT - IV

FINITE VOLUME METHOD: Finite volume method via finite difference method, formulations for two and three-dimensional problems.

UNIT - V

STANDARD VARIATIONAL METHODS: Linear fluid flow problems, steady state problems, Transient problems.

TOTAL: 45 PERIODS

REFERENCES:

1. Versteeg, H. K. and Malalasekera, W., An Introduction to Computational Fluid Dynamics: The Finite Volume Method, 2nd Edition, Pearson, 2010.
2. Tannehill, J. C., Anderson, D. A. and Pletcher, R. H., Computational Fluid Mechanics and Heat Transfer,McGraw Hill, 2002.
3. Blazek, J., Computational Fluid Dynamics: Principles and Applications, 2nd Edition, Elsevier Science &Technology, 2006.
4. Chung, T. J., Computational Fluid Dynamics, Cambridge University Press, 2003
5. Text book of fluid dynamics/ Frank Choriton/ CBS Publishers & distributors, 1985
6. Numerical heat transfer and fluid flow / Suhas V. Patankar/ Hema shava Publishers corporation & Mc Graw Hill.

7. Computational Fluid Flow and Heat Transfer/ Muralidaran/ Narosa Publications
8. Fundamentals of Computational Fluid Dynamics/Tapan K. Sengupta / Universities Press.
9. Introduction to Theoretical and Computational Fluid Dynamics/C. Pozrikidis /Oxford University Press/2nd Edition

TE15A7 COLD CHAIN TECHNOLOGY 3 0 0 3

UNIT I - GENERAL PRINCIPLES OF FOOD PRESERVATION 9

Introduction to Process operations, principles, good manufacturing practices, Food Laws and Regulations, Principles of food preservation, Asepsis, removal of microorganisms, Maintenance of anaerobic conditions, Methods of food preservation

UNITII - WATER ACTIVITY AND FOOD PRESERVATION AND PRESERVATION THROUGH TEMPERATURE REDUCTION: 9

Storage of food at chilling temperature – behavior, Refrigeration, Controlled Atmosphere Storage (CAS), Modified Atmosphere Storage (MAS), Chilling defects Freezing –principles, fundamental aspects of freezing, Freezing process –technological aspects, Freezing damage - osmotic damage, solute damage, Structural damage, Concentration of food, Evaporation, Freeze concentration, Membrane process for concentration

UNIT III - DEHYDRATION OF FOOD 9

Transport of water in foods, Different methods of dehydration, Cabinet drying, sun / solar drying, Osmo drying, Osmo - vac drying, microvac drying, vacuum drying, Nutritional, physico-chemical changes during drying Quality aspects of dehydrated food., Recent advances in dehydration of food Freeze drying,- Introduction, principles, process and Preservation,- Physico-chemical changes in food,- Nutritional changes during freeze drying,- Recent advances in freeze drying methods(industrial developments)

UNIT IV - PRESERVATION USING HIGH SUGAR AND SALTS 9

Jam, Jellies Squashes, syrups, marmalades, cordials,concentrate etc.• Intermediate moisture fruits(candies / murambas,tutti-frutti /glazed fruits), Use of common salt, principle, process, Fish salting, Pickling,- Pickle salting (sauerkraut, cucumber, Kimchi),- Vegetable salting,Acidified – brined pickles (vegetables-onion, garlic)

UNIT V - FERMENTATION PROCESS 9

Pickle making technology, Wine making technology (grape and others), Beer making,Traditional fermented food products- Dhokla, Idli, Curd, Tempe, Soya sauce - fish, meat and vegetable fermentedproducts, Various alcohol based products, Yeast fermented,Industrial Applications, Food Plant Sanitation, Environmental Aspects of Food Processing,Roles and scientific use of water in food processing,Food processing waste management

TOTAL: 45 PERIODS

REFERENCE BOOKS :

1. Mircea Enachescu Dauthy (1997) ‘Fruit and vegetable processing’, FAO Agricultural Services Bulletin 119, International Book Distributing Co.
2. Brain J.B. Wood (1985) Microbiology of Fermented Foods, Vol. I, Elsevier Applied Science Publishers.

3. Diane M Barrett, Laszlo Somogyi, Hoshahalli Ramaswamy Processing Fruits, II edition, Science and Technology, CRC Press.
4. Marcus Karel, Owen R Fernnema Physicalprinciples Food Science, Part I and II Marcel Dekker inc.
5. IGNOU-2006 Food Processing and Engineering –II, Practical Mannual, www.ignou.ac.in.
6. Giridhari Lal, G.S. Siddappa and G. L. Tondon Preservation of Fruits and Vegetables, CFTRI , ICAR , New Delhi -12.

TE15A8 CRYOGENIC ENGINEERING 3 0 0 3

UNIT I - INTRODUCTION TO CRYOGENIC SYSTEMS: **9**

INTRODUCTION TO CRYOGENIC SYSTEMS: Mechanical Properties at low temperatures. Properties of Cryogenic Fluids. Gas Liquefaction: Minimum work for liquefaction. Methods to protect low temperature. Liquefaction systems for gages other than Neon. Hydrogen and Helium.

UNIT IIGAS LIQUEFACTION SYSTEMS& CRYOGENIC INSULATION: **9**

Recuperative – Linde – Hampson, Claude, Cascade, Heylandt, Kapitza, Collins, Simon; Regenerative – Stirling cycle and refrigerator, Slovay refrigerator, Gifford-McMahon refrigerator, Vuilleumier refrigerator, Pulse Tube refrigerator; Liquefaction of natural gas.
Vacuum insulation, Evacuated porous insulation, Gas filled Powders and fibrous materials, Solid foams, Multilayer insulation, Liquid and vapour Shields, Composite insulations.

UNIT III - STORAGE OF CRYOGENIC LIQUIDS: 9

Design considerations of storage vessel; Dewar vessels; Industrial storage vessels; Storage of cryogenic fluids in space; Transfer systems and Lines for cryogenic liquids; Cryogenic valves in transfer lines; Two phase flow in Transfer system; Cool-down of storage and transfer systems.

UNITIV -CRYOGENIC INSTRUMENTATION&CRYOGENIC EQUIPMENT: **9**

Measurement of strain, pressure, flow, liquid level and Temperature in cryogenic environment; Cryostats. Cryogenic heat exchangers – recuperative and regenerative; Variables affecting heat exchanger and system performance; Cryogenic compressors, Pumps, expanders; Turbo alternators; Effect of component inefficiencies; System Optimization, 3He-4He Dilution refrigerator; Cryopumping;

UNIT V - APPLICATIONS: 9

APPLICATIONS: Space technology, In-Flight air separation and collection of LOX, Gas industry, Biology, Medicine, Electronics.

TOTAL: 45 PERIODS

REFERENCE BOOKS

1. Cryogenics: Applications and Progress, A. Bose and P. Sengupta, Tata McGraw Hill.
2. Cryogenic Engineering, T.M. Flynn, Marcel Dekker
3. Handbook of Cryogenic Engineering, Editor – J.G. Weisend II, Taylor and Francis
4. Cryogenic Systems, R. Barron, Oxford University Press.
5. Cryogenic Process Engineering, K.D. Timmerhaus and T.M. Flynn, Plenum Press.
6. Cryogenic Fundamentals, G.G. Haselden, Academic Press.
7. Advanced Cryogenics, Editor – C.A. Bailey, Plenum Press.

8. Applied Cryogenic Engineering, Editors – R.W. Vance and W.M. Duke, John Wiley & sons.

TE15A9 AIR CONDITIONING SYSTEM DESIGN 3 0 0 3

UNIT I -AIR CONDITIONING SYSTEMS 9

Hydronic Piping Systems And Terminal Units: Scope of air conditioning, All-water (Hydronic) air- conditioning systems, All-air air- conditioning systems, Human comfort, Comfort standards, Hydronic piping systems -Piping arrangements, Series loop, One-pipe main, Two-pipe direct and revere returns,Three-pipe and four pipe systems, Terminal units-Radiators, Convectors, Baseboard,Fin-tube, Radiant panels, Unit heaters, Fan-coil and induction units, Selection of terminal units, System design procedure.

UNIT II - HEAT TRANSFER IN BUILDING STRUCTURES AND LOAD CALCULATION: 9

Fabric heat gain, Overall heat transfer coefficient, Periodic heat transfer through walls and roofs, Empirical methods to evaluate heat transfer through wall and roofs, Infiltration, Passive heating and cooling of buildings, Internal heat gains, System heat gains, Break-up of ventilation load and effective sensible heat factor, cooling-load estimate, Heating-load estimate, Psychometric calculations for cooling.

UNIT III - PSYCHOMETRIC ANALYSIS OF THE AIR CONDITIONING SYSTEM: 9

Determining moist air properties, The psychrometric chart, Air conditioning processes, Determining supply air conditions, Sensible heat ratio, The RSHR or condition line, Coil process line, The contact factor and bypass factor, The effective surface temperature, Reheat, Part load operation and control, Fan heat gains, Comfort chart.

UNIT IV - FLUID FLOW IN PIPING AND DUCTS: 9

The continuity equation, The flow energy equation, Pressure loss in closed and open systems, Total, static and velocity pressures in piping, Pressure loss in pipe fitting, System pipe sizing, Friction loss from air flow in ducts, duct fittings at fan inlet and outlet, Duct system pressure loss, Duct design methods.

UNIT V FANS, AIR DISTRIBUTION DEVICES AND PLANNING AND DESIGNING: 9

Fan - Types, Performance characteristics, Selection, Ratings, Selection of optimum conditions, Laws, Arrangement and installation, Air distribution devices Air patterns,Location, Types, Selection, Accessories, Return air devices, Sound and its control,PumpsTypes, Characteristics, Similarity laws, Net positive suction head, The expansion and compression tanks, Air control and venting.

Classification of A/C systems- Single zone, Reheat, Multi zone, Dual duct, Variable air volume, All-water systems, Air water systems, Unitary air conditioners, Rooftop units, Air handling units, Procedures for designing a hydronic system, Calculating the heating load, Type, location and selection of terminal units, Piping system arrangements, Flow rates and temperature, Pipe sizing, Duct layout, Pump selection, Boilers selection, Compressor tanks, Procedure for designing and all-air system, Calculating the cooling load, Type of system, Equipment and duct locations, Duct sizes, Air distribution devices,

TOTAL: 45 PERIODS

REFERENCE BOOKS

1. Air Conditioning Principles and Systems by Edward G. Pita, Published by PHI, New Delhi
2. Refrigeration and Air Conditioning by C.P. Arora, Published by TMH, New Delhi.
3. Refrigeration and Air Conditioning by W.F. Stocker and J.W. Jones, Published by TMH, New Delhi.
4. Refrigeration and Air Conditioning by Manohar Prasad, , Published by Wiley Eastern Limited, New Delhi.

TE15B1 ADVANCED INTERNAL COMBUSTION ENGINEERING 3 0 0 3

UNIT-I Introduction – Historical Review – Engine Types – Design and operating Parameters. Cycle Analysis: Thermo-chemistry of Fuel – Air mixtures, properties – Ideal Models of Engine cycles – Real Engine cycles - differences and Factors responsible for – Computer Modeling.

UNIT-II - GAS EXCHANGE PROCESSES 9

Volumetric Efficiency – Flow through ports – Supercharging and Turbo charging. Charge Motion: Mean velocity and Turbulent characteristics – Swirl, Squish – Pre-chamber Engine flows.

UNIT-III- ENGINE COMBUSTION IN S.I ENGINES 9

Combustion and Speed – Cyclic Variations – Ignition – Abnormal combustion Fuel factors, MPFI, SI engine testing.

Combustion in CI engines: Essential Features – Types off Cycle. Pr. Data – Fuel Spray Behavior – Ignition Delay – Mixing Formation and control, Common rail fuel injection system

UNIT-IV- POLLUTANT FORMATION AND CONTROL

Nature and extent of problems – Nitrogen Oxides, Carbon monoxide, unburnt Hydrocarbon and particulate – Emissions – Measurement – Exhaust Gas Treatment, Catalytic converter, SCR, Particulate Traps, Lean, NOx, Catalysts.

UNIT-V- ENGINE HEAT TRANSFER

Importance of heat transfer, heat transfer and engine energy balance, Convective heat transfer , radiation heat transfer, Engine operating characteristics. Fuel supply systems for S.I. and C.I engines to use gaseous fuels like LPG, CNG and Hydrogen. Modern Trends in IC Engines: Lean Burning and Adiabatic concepts, Rotary Engines, Modification in I.C engines to suit Bio – fuels, HCCI and GDI concepts.

TOTAL: 45 PERIODS

REFERENCE BOOKS

1. E.F. Obert, “Internal Combustion Engines and Air Pollution”, Intext Educational Publishers, 1973.
2. Yadav, R., I. C. Engines and Air Pollution, Central Publishing House, 2002
3. Maleev, V. L., Internal Combustion Engines, McGraw Hill Book Company, New York, 1987.
4. C.F. Taylor and E.S. Taylor, “Internal Combustion Engine”, Stanton, 1961.

5. P.G. Burman and B. Luca, “Fuel Injection and Controls of I.C. Engines”, Technical Press, 1962.
6. V. Ganeshan, “Internal Combustion Engines”, Tata McGraw Hill, New Delhi, 1996.
7. C.R. Fergusson & A.R. Kirkpatrick, “Internal Combustion Engines”, Delhi, 2001.
8. Internal Combustion Engines, C.R. Ferguson & A.R. Kirkpatrick,Delhi,2001

TE15B2 TRANSPORT PHENOMENA 3 0 0 3

UNIT I- BASIC EQUATIONS OF FLOW 9

Pressure - Kinetic & Datum Energy - Bernoulli's Theorem - Deduction of Bernoulli's Theorem – Eulers Equations for motion - Limitations of Bernoulli's Theorem - Practical Applications of Bernoulli's Theorem - Liquid jet & syphon - Momentum Equation - Forced and Free Vortex

UNIT II REYNOLD'S ANALYSIS & BOUNDARY LAYER CONCEPT 9

Reynold's Experiment - Laminar and Turbulent Flow -Reynold's Number - Navier Stoke's Equation of Motion -Laminar Flow between Parallel Plates - Waojuen - Poiseuille's Equation for Flow through Circular Pipes -Turbulence - Darcy Weisbach Equation for Flow Through Circular Pipe - Friction Factor - Smooth and RoughPipes - Moody Diagram - Uses due to Contraction / Expansion etc., Pipes in Series & Parallel - EconomicalDiameter of Pipe Transmission of Power.Boundary Layer - Displacement & Momentum Thickness - Laminar & Turbulent Boundary Layers in Flat Plates- Velocity Distribution in Turbulent Flows in Smooth and Rough Boundaries - Laminar Sub Layer

UNIT III -TRANSPORTATION OF FLUIDS, INTERPHASE AND MULTIPHASE MOMENTUM TRANSFER 9

Types of Centrifugal and Reciprocating Pumps - Comparision of Centrifugal and Reciprocating Pumps. Industrial Pipe Systems - Selection of Fans, Blowers, Pumps and Compressors - Efficiency Prediction - Pressure Drop Characteristics - Friction Factor, Fluid - Fluid System Flow Patterns in Vertical and Horizontal Pipes. Formation of Bubbles and Drops and their Size Distribution, Solid - Fluid Systems - Forces acting on Stagnant and Moving Solids. Flow through Porous Medium. Capillary Tube Model and its Applications for Packed Bed and Filters, Fluidised Bed, Solid Fluid Conveying Settling and Sedimentation

UNIT IV- INTERPHASE TRANSPORT IN NON-ISOTHERMAL SYSTEMS AND RADIATION HEAT TRANSFER 9

Heat Transfer Co-efficient, Forced Convection in Tubes, around Submerged Objects, through Packed Beds. Heat Transfer by Free Convection, Film Type and Drop wise Condensation Equations for Heat Transfer Coefficients for both, Heat Transfer in Boiling Liquids

UNIT V- INTERPHASE MASS TRANSPORT AND MACROSCOPIC BALANCES FOR MULTICOMPONENT SYSTEM 9

Mass transfer coefficient in one and two phases at low and high mass transfer rates, film theory penetration theory, boundary layer theory, fixed bed catalytic, reactor, macroscopic balances to solve steady and unsteady state problems

TOTAL: 45 PERIODS

REFERENCEBOOKS

1 .Bansal, Fluid Mechanics, Saurabh & Co., New Delhi, 1985

2. Arora KR, Fluid Mechanics, Hydraulics & Hydraulic Machines, Standard Publishers, New Delhi, 1976
3. Jagadish Lal, Hydraulics & Fluid Mechanics, 2nd Edition Revised & Enlarged, Metropolitan Book Co,
New Delhi
4. P.N. Modi & SM Seth, Hydraulics & Fluid Mechanics, 8th Edition, Standard Book House, 1987
5. Natarajan MK, Principles of Fluid Mechanics, Oxford & IBH Publishers, 1984

WEBSITES:
1. http ://www.gbhp.com
2. http ://www.owlnet.rice.edu

TE15B3 TECHNOLOGY MANAGEMENT 3 0 0 3

1. INTRODUCTION 9
Technology management - Scope, components, and overview. Technology and environment, Technology and society, Technology Impact analysis, environmental, social, legal, political aspects, techniques for analysis - steps involved. Technology policy strategy: Science and technology Policy of India, implications to industry, The dynamics of technology change

2. TECHNOLOGY FORECASTING 9
Need, methodology and methods - trend Analysis, Analogy, Delphi, Soft System Methodology, Mathematical Models, Simulation, and System Dynamics.

3. TECHNOLOGY CHOICE AND EVALUATION 9
Issues in the development new high tech products, Methods of analyzing alternate technologies, Techno-economic feasibility studies, Need for multi-criteria considerations such as, social, environmental, and political, Analytic hierarchy method, Fuzzy multi-criteria decision making, and other methods.

4. TECHNOLOGY TRANSFER AND ACQUISITION 9
Import regulations, Implications of agreements like Uruguay Round and WTO, Bargaining process, Transfer option, MOU- Technology Adoption and Productivity - Adopting technology-human interactions, Organisational redesign and re-engineering, Technology productivity.

5. TECHNOLOGY ABSORPTION AND INNOVATION 9
Present status in India, Need for new outlook, Absorption strategies for acquired technology, creating new/improved technologies, Innovations, Technology Measurement- Technology Audit, Risk and exposure, R&D portfolio management

TOTAL: 45 PERIODS

REFERENCES:
1. Joseph M. Putti, Management – A Functional Approach, McGraw Hill, 1997
2. Kenneth C. Lauden , MIS: Organisation and Technology, Prentice Hall, 1995
3. James A.Senn, Information technology in Business, Prentice Hall, 1995
4. Ronald J. Jordan, Security analysis and Portfolio Management, Prentice Hall, 1995
5. Irvin M. Rubin, Organisational behavior an experimental approach, Prentice Hall, 1995
6. Gerard H. Gaynor, Handbook of Technology Management, McGraw-Hill Professional, 1996

TE15B4 FLUIDIZED BED SYSTEM DESIGN 3 0 0 3

UNIT-I FLUIDIZED BED BEHAVIOUR: 9

Fluidization Phenomena - Regimes of Fluidized Bed Behaviour - Characterization of Fluidized Particles - Two Phase and Well Mixed Theory of Fluidization - Solids Mixing - Particle Entrainment and Carryover.

UNIT-II HEAT TRANSFER: 9

Different Modes of Heat Transfer in Fluidized Bed - Use of Immersed Tubes - Finned Tubes - Heat Recovery Systems.

UNIT-III COMBUSTION AND GASIFICATION: 9

Fluidized Bed Combustion and Gasification Pressurised Systems, Sizing of Combustion and Gasification Systems, Start-up Methods, Fast Fluidized Beds, Different Modes of Heat Transfer in Fluidized Beds.

UNIT-IV SYSTEM DESIGN: 9

Design of Distributors, Fluidized Bed Furnaces for Fossil and Agricultural Fuels, Fluidized Bed Heat Recovery Systems, Fluid Bed Dryers.

UNIT-V INDUSTRIAL APPLICATIONS: 9

Sulphur Retention - Nitrogen Emission Control - Furnaces, Dryers, Heat Treatment, etc. Pollution Control and Environmental Effects - Cost Analysis

TOTAL: 45 PERIODS

REFERENCES:

1. Howard, J.R., Fluidized Bed Technology: Principles and Applications, Adam Hilger, New York, 1983.
2. Geldart, D, Gas Fluidization Technology, John Wiley & Sons, New York, 1986.
3. Howard, J.R. (Ed), Fluidized Beds : Combustion and Applications, Applied Science Publishers, New York 1983.
4. Yates, J.G. Fundamentals of Fluidized bed Chemical Processes, Butterworths, 1983.
5. Reed, T.B., Biomass Gasification : Principles and Technology, Noyes Data Corporation, New Jersey, 1981.

TE15B5 ADVANCED FINITE ELEMENT ANALYSIS 3 0 0 3

UNIT-I

Introduction to FEM, basic concepts, historical back ground, applications of FEM, general description, comparison of FEM with other methods, variational approach, Glerkin's Methods. Co-ordinates, basic element shapes, interpolation function, Virtual energy principle, Rayleigh – Ritz method, properties of stiffness matrix, treatment of boundary conditions, solution of system of equations, shape functions and characteristics, Basic equations of elasticity, strain- displacement relations.

UNIT-II

1-D STRUCTURAL PROBLEMS: Axial bar element – stiffness matrix, load vector, temperature effects, Quadratic shape functions and problems. ANALYSIS OF TRUSSES :

Plane Trusses and Space Truss elements and problems ANALYSIS OF BEAMS : Hermite shape functions – stiffness matrix – Load vector – Problems.

UNIT-III

2-D PROBLEMS: CST, LST, force terms, Stiffness matrix and load vectors, boundary conditions, Isoparametric elements – quadrilateral element, shape functions – Numerical Integration. Finite element modeling of Axi-symmetric solids subjected to Axi-symmetric loading with triangular elements. 3-D PROBLEMS: Tetrahedran element – Jacobian matrix – Stiffness matrix.

UNIT-VI

SCALAR FIELD PROBLEMS: 1-D Heat conduction-Slabs – fins - 2-D heat conduction problems – Introduction to Torsional problems.

UNIT-V

Dynamic considerations, Dynamic equations – consistent mass matrix – Eigen Values, Eigen vector, natural frequencies – mode shapes – modal analysis.

REFERENCES:

1. Rao, S. S., The Finite Element Method in Engineering, 5th Edition, Elsevier 2011.
2. Nithiarasu, P., Seetharamu, K. N. and Lewis, R. W., The Finite Element Method for Heat Transfer Analysis,John Wiley and Sons, 2004.
3. Reddy, J. N. and Gartling D. K., The Finite Element Method in Heat Transfer and Fluid Dynamics, 3rd Edition, CRC Press, 2010.
4. Introduction to Finite Elements in Engineering, Chandrupatla, Ashok and Belegundu, Prentice – Hall
5. Finite Element Method – Zincowitz / Mc Graw Hill
6. A First Course in the Finite Element Method/Daryl L Logan/Cengage Learning/5th Edition
7. Finite Element Method – Krishna Murthy / TMH
8. Finite Element Analysis – Bathe / PH

TE15B6 JET PROPULSION AND ROCKETRY 3 0 0 3

UNIT - I:

TURBO JET PROPULSION SYSTEM: Gas turbine cycle analysis – layout of turbo jet engine. Turbo machinery- compressors and turbines, combustor, blade aerodynamics, engine off design performance analysis. Flight Performance: Forces acting on vehicle – Basic relations of motion – multi stage vehicles.

UNIT - II:

PRINCIPLES OF JET PROPULSION AND ROCKETRY: Fundamentals of jet ropulsion, Rockets and air breathing jet engines – Classification – turbo jet , turbo fan, turbo prop, rocket (Solid and Liquid propellant rockets) and Ramjet engines. Nozzle Theory and Characteristics Parameters: Theory of one dimensional convergent – divergent nozzles – aerodynamic choking of nozzles and mass flow through a nozzle – nozzle exhaust velocity – thrust, thrust coefficient, Ac / At of a nozzle, Supersonic nozzle shape, non-adapted nozzles, summer field criteria, departure from simple analysis – characteristic parameters – 1) characteristic velocity, 2) specific impulse 3) total impulse 4) relationship between the characteristic parameters 5) nozzle efficiency, combustion efficiency and overall efficiency.

UNIT - III:

AERO THERMO CHEMISTRY OF THE COMBUSTION PRODUCTS: Review of properties of mixture of gases – Gibbs – Dalton laws – Equivalent ratio, enthalpy changes in reactions, heat of reaction and heat of formation – calculation of adiabatic flame temperature and specific impulse – frozen and equilibrium flows. Solid Propulsion System: Solid propellants – classification, homogeneous and heterogeneous propellants, double base propellant compositions and manufacturing methods. Composite propellant oxidizers and binders. Effect of binder on propellant properties. Burning rate and burning rate laws, factors influencing the burning rate, methods of determining burning rates.

UNIT - IV:

Solid propellant rocket engine – internal ballistics, equilibrium motor operation and equilibrium pressure to various parameters. Transient and pseudo equilibrium operation, end burning and burning grains, grain design. Rocket motor hard ware design. Heat transfer considerations in solid rocket motor design. Ignition system, simple pyro devices. Liquid Rocket Propulsion System: Liquid propellants – classification, Mono and Bi propellants, Cryogenic and storage propellants, ignition delay of hypergolic propellants, physical and chemical characteristics of liquid propellant. Liquid propellant rocket engine – system layout.pump and pressure feed systems, feed system components. Design of combustion chamber, characteristic length, constructional features, and chamber wall stresses. Heat transfer and cooling aspects. Uncooled engines, injectors – various types, injection patterns, injector characteristics, and atomization and drop size distribution, propellant tank design.

UNIT - V:

RAMJET AND INTEGRAL ROCKET RAMJET PROPULSION SYSTEM: Fuel rich solid propellants, gross thrust, gross thrust coefficient, combustion efficiency of ramjet engine, air intakes and their classification – critical, super critical and sub-critical operation of air intakes, engine intake matching, classification and comparison of IIRR propulsion systems.

TOTAL: 45 PERIODS

REFERENCES:

1. Mechanics and Dynamics of Propulsion/ Hill and Peterson/John Wiley & Sons
2. Rocket propulsion elements/Sutton/John Wiley & Sons/8th Edition
3. Gas Turbines/Ganesan /TMH
4. Gas Turbines & Propulsive Systems/Khajuria & Dubey/Dhanpat Rai & Sons
5. Rocket propulsion/Bevere/
6. Jet propulsion /Nicholas Cumpsty/ Tansfer and cooling aspects.

Uncooled engines, injectors – various types, injection pat