PROGRAM STRUCTURE FOR

ME MECHANICAL (THERMAL & HEAT POWER ENGINEERING)

Swami Ramanand Teerth Marathwada University, NANDED. (M.S.)

SEMESTER – I

Sr. No.	SUBJECT	TEACHING (Hrs/Week)			EXAMINATION (MARKS)			
		TH	PR	Total	Test/ oral	Paper	Term Work	Total
1	Numerical Methods for Thermal and Heat Power Engineering	4	-	4	25	100		125
2	Advanced Thermodynamics	4	-	4	25	100		125
3	Advanced Heat Transfer-I	4	-	4	25	100		125
4	Energy Conservation -I	4	-	4	25	100		125
5	Elective – I	4	-	4	25	100	-	125
6	Seminar – I	-	2	2	-	-	50	50
7	Thermal Lab- I	-	2	2	25	-	50	75
	Sub Total - I	20	4	24	150	500	100	750

Elective – I

1. Advanced Refrigeration
2. I.C.Engine - I
3. Waste heat recovery
4. Environmental Engineering & Pollution Control.

SEMESTER - II

Sr. No.	SUBJECT	TEACHING (Hrs/Week)			EXAMINATION (MARKS)			
		TH	PR	Total	Test/ oral	Paper	Term Work	Total
8	Advanced Heat transfer - II	4	-	4	25	100		125
9	Energy Conservation -II	4	-	4	25	100		125
10	Design of Heat Exchanger	4	-	4	25	100		125
11	Computational Fluid Dynamics	4	-	4	25	100		125
12	Elective – II	4	-	4	25	100	-	125
13	Seminar – II	-	2	2	-	-	50	50
14	Thermal Lab- II	-	2	2	25	-	50	75
	Sub Total - II	20	4	24	150	500	100	750

Elective II

1. Cryogenic Engineering
2. Advanced Air-Conditioning Systems
3. I.C.Engine – II
4. Advanced Fluid Mechanics

SEMESTER –III

Sr. No.	SUBJECT	TEACHING (Hrs/Week)			EXAMINATION (MARKS)			
		TH	PR	Total	Test/ oral	Paper	Term Work	Total
15	Seminar and Project - I	-	-	-	50	-	50	100
	Sub Total - III				50		50	100

SEMESTER - IV

Sr. No.	SUBJECT	TEACHING (Hrs/Week)			EXAMINATION (MARKS)			
		TH	PR	Total	Test/ oral	Paper	Term Work	Total
16	Dissertation (Project – II)	-	-	-	100	-	200	300
	Sub Total - IV				100		200	300
	GRAND TOTAL (I,II,III,IV)							**1900**

NUMERICAL METHOD IN THERMAL AND HEAT POWER ENGINEERING

Teaching Scheme : 4 hrs/week

Examination Paper : 100 Marks
Paper Duration : 3 hrs.

I. **Roots of equations :** Bisection Method, False position method, Newton – Raphson Method, Muller's method, Bairstow's Method.

II. **Linear Algebraic Equations** : Gauss – Elimination, gauss –Seidel, LU Decomposition

III. **Curve fitting:** Least Square regression :-
Linear regression, multiple linear regression, polynomial regression.
Interpolation: Newton's Divided Difference Lagrange's Inverse, Spline, Hermite Interpolation, Extrapolation technique of Richardson's Gaunt.

IV. **Differentiation & Integration :** Divided difference formulae, Romberg integration, Gauss Quadrature for double & triple integration.

V. **Ordinary differential equations :** Euler's method, Heun's method, Mid – point method, Runge – Kutta methods, Multi step methods- explicit Adams – Bashforth technique & Implicit Adams – Molution Technique, Adaptive RK method, Embedded RK method. Step size control, Higher order ODE – Shooting method. Non linear ODE – Collocation technique.

VI. **Partial Differential Equations :** Solution of parabolic and Hyperbolic equations – Implicit & Explicit Schemes, ADI methods, Non Linear parabolic equations – Iteration method. Solution of elliptic equation – Jacobi method, gauss – Seidel & SOR method. Richardson method.

*Numerical methods should have orientation in Thermal and Heat Power Engineering

Reference Books :

1. Numerical Methods for Engineers, Steven C Chapra & Raymond P Canale, TMH, Fifth Edition.
2. Applied Numerical Methods, Alkis Constatntinides, McGraw Hill
3. Numerical Solution of Differential Equationsm M.K.Jain, 2nd Editions, Wiley Eastern.
4. Numerical Methods for scientific and engineering computation, Jain, Iyangar, Jain, New Age International Publishers.
5. Numerical methods in Engineering and Science, Dr. B.S.Garewal, Khanna Publishers.

ADVANCED THERMODYNAMICS

Teaching Scheme : 4 hrs/week

Examination Paper : 100 Marks
Paper Duration : 3 hrs.

I. Equation of state

State postulate for Simple System and equation of state, Ideal gas equation, Deviation from ideal gas, Equation of state for real gases, generalized Compressibility chart, Law of corresponding states

Properties of Pure Substances
Phase change process of pure substances, PVT surface, P-V & P-T diagrams, Use of steam table and charts in common use

II. Laws of Thermodynamics, 2nd law Analysis for Energy, Systems, Entropy flow & Entropy generation, Increase of entropy principle, entropy change of pure sub, T-ds relations, entropy generation, thermo electricity, Onsager equation. Energy analysis of thermal systems, decrease of Exergy principle and Exergy destruction

III. Thermodynamics Property Relations

Partial Differentials, Maxwell relations, Clapeyron equation, general relations for du, dh, ds, and Cv and Cp. Joule Thomson Coefficient, Δh, Δu, Δs of real gases.

IV. Chemical Thermodynamics

Chemical reaction – Fuels and combustion, Enthalpy of formation and enthalpy of combustion, First law analysis of reacting systems, adiabatic flame temperature Chemical and phase equilibrium – Criterion for chemical equilibrium, equilibrium constant for ideal gas mixtures, some remarks about Kp of Ideal-gas mixtures, fugacity and activity, Simultaneous relations, Variation of Kp with Temperature, Phase equilibrium, Gibb's phase rule, Third law of thermodynamics, Nerst heat theorem and heat death of universe.

V. Gas Mixtures – Mass & mole fractions, Dalton's law of partial pressure, Amagat's law, Kay's rule.

VI. Statistical Thermodynamics – Fundamentals, equilibrium distribution, Significance of Lagrangian multiples, Partition function for Canonical Ensemble, partition function for an Ideal monatomic gas, equipartition of energy, Bose Einstein statistics, Fermi-Dirac statistics.

Reference Books :

1. Cengel, Thermodynamics, TMH
2. Howell & Dedcius : Fundamentals of engineering Thermodynamics, McGraw Hill, Inc, USA
3. Van Wylen & Sontag : thermodynamics, John Wiley & Sons, Inc, USA
4. Holman, Thermodynamics, 4^{th} edition, McGraw Hill
5. Zimmansky & Dittman, Heat and Thermodynamics, 7^{th} edition, TMH
6. Rao, Y.V.C. Postulational and Statistical thermodynamics, Allied Pub. Inc.
7. Jones and Hawkings : engineering Thermodynamics, John Wiley & Sons, Inc, USA
8. Faires V.M and Simmag : Thermodynamics, Mcmilan Pub. Co,Inc. USA
9. Turns, Thermodynamics – Concepts and Applications, Cambridge University Press.
10. Wark, Advanced Thermodynamics, McGraw Hill
11. Nag P.K., Basic & Applied Thermodynamcis, TMH, New Delhi
12. Jones & Dugan, Advanced Thermodynamics, Prentice hall Int.
13. Bejan, Advanced Thermodynamics, John Wiley, Inc.

ADVANCED HEAT TRANSFER - I

Teaching Scheme : 4 hrs/week

Examination Paper : 100 Marks
Paper Duration : 3 hrs.

I. **Steady state conduction :** Basic fundamentals, One dimensional steady state conduction , three dimensional steady state conduction, critical radius of insulation.

II. **Fins** : Fins of uniform & non-uniform cross section, Fin effectiveness & efficiency, temperature measurement, Numerical analysis.

III. **Unsteady state heat conduction :** Applicability of Heisler charts, Semi-infinite slab and cylinder suddenly exposed to convection. Transient numerical methods. Thermal resistance and capacity formulation.

IV. **Conduction with internal heat generation:** Plane wall, hollow cylinder, solid cylinder, solid sphere with uniform heat generation. Electrical wire carry current, variable distribution of generation as a function of position and temperature. Dielectric heating.

V. **Radiation :** Introduction to basic fundamentals, Radiation shape factor, Heat exchange between black & non-black bodies using network approach.

VI. **Gas radiation** : Gas radiation network for an absorbing and transmitting medium, radiation shield, Effect of radiation on temperature measurement, Radiation heat transfer coefficient.

Note : Heat transfer data book will be permitted in Exam Hall

Reference Books :

1. Heat transfer by J.P.Holman, Tata McGraw Hill publication, 9th edition 2012.
2. Heat transfer by P.K.Nag, Tata McGraw Hill Publication, 2005.
3. Heat transfer by S.P.Sukhatme, Tata Mc-Graw Hill Publication, 1994.
4. Heat and Mass Transfer Data Book Book by C.P.Kothandaraman, S.Subramanyam, New age International, 1994.
5. Heat Transfer data book Convective heat & mass transfer by Kays and Crawford, Tata.

ENERGY CONSERVATION – I

Teaching Scheme : 4 hrs/week

Examination Paper : 100 Marks
Paper Duration : 3 hrs.

I. **Steam Turbines** : Power plant cycles, cycle analysis and design losses in steam turbines, Performance at various loads, governing, operation and management
Fluidized bed combustion, sizing of power plant components : steam generator, condenser, cooling tower, turbines etc.

II. Nuclear reactor fundamentals, Nuclear Power plant types, safety in nuclear power plants, enrichment of fuels, heavy water facilities.

III. Combined cycle power plants, cogeneration plants, Gas Turbine power plant, combustor, pollution control techniques, diesel engine power plants.

IV. Hydropower and its constraints, environmental and social impacts, selection of components, Mini and micro Hydal power plants.

V. Energy storage : need, different systems, thermal storage, hybrid air storage system, fuel cell, latent heat storage systems, hydrogen energy systems etc.

VI. Instrumentation system used, clean energy technology, projection of energy demands and planning of different plants, load management.

Reference Books :

1. Power plant Engineering : P.K.Nag, Tata McGraw Hill, III edition, 2007
2. An Introduction to power plant engineering, G.D.Rai, Khanna Publishers, III edition, 2001
3. Hydropower development series, Vol.1.17, Norwejian Institute of Technology, 1996/2005.
4. Combined cycle Gas and Steam Turbine Power Plant, Rolf H Kohlhofer, Penn Well Books, 1991.
5. Standard Handbook of Power Plant Engineering, Thomas C Elliot, Robert C, Swanekamp, Kao Chen, McGraw hill Professional, 1997
6. Wet steam turbines for Nuclear Power Plants, Aleksander Lejzerovic, Penn Well Books, 2005.
7. TMI 25 Years Later : the Three Mile Island nuclear power plant and its impact, Bonnie Anne Osif, Anthony Baratta, Thomas W Conkling, Penn State Press, 2004

ELECTIVE – I

1. ADVANCED REFRIGERATION

Teaching Scheme : 4 hrs/week

Examination Paper : 100 Marks
Paper Duration : 3 hrs.

I. **Vapour Compression Refrigeration :** Standard cycle : Effects of operating conditions-suction and condensing temperature, Actual cycle; Second Law Efficiency of the cycle; Liquid-Vapour regenerator.

II. **Multipressure Systems :** Multistage compression with flash inter-cooling and closed inter-cooling; Multi-evaporator systems with individual and multiple expansion valves; Cascade systems and their optimum coupling temperature;. Performance characteristics and capacity control of compressors; Compressor rating and selection; Introduction & principle of working of Screw compressor and Scroll compressor.

III. **System Components & Controls :** Design, selection and capacity of evaporators; Air-cooled condensers. Water-cooled condensers and Evaporative condensers with their rating and selection;. System balance, Balancing between Compressor and Condenser, Balancing between compressor and Evaporator, Refrigeration Control Systems, Control switches, Pressure regulators, solenoid valves, Control applications; Three phase induction motors-; Hermetic Motors; Synchronous motors; Thermal overload protection, Motor over-current protection; Thermal overload protection, motor over-current protection; Motor replacement; Motor selection.

IV. **Refrigerants :** Designation and selection of refrigerants; desirable thermodynamics, physical and chemical properties of a refrigerant; CFC/HCFC phase-out regulations, Montreal and Kyoto Protocols; Alternative eco-friendly Refrigerants; Retrofits with alternative refrigerants; Refrigeration lubricant requirements.

V. **Vapour Absorption Refrigeration System :** Standard cycle; Actual cycle and its representation on enthalpy – concentration diagram; Thermodynamics analysis of vapour absorption cycle; Ammonia – water – lithium bromide systems; single effect/ double effect system; practical absorption chiller; alternative working fluids for absorption system; Capacity control

VI. **Air Refrigeration System :** Bell Coleman Cycle; Aircraft refrigeration systems-simple, Boot strap, regenerative and reduced ambient; Analysis of an aircraft refrigeration cycle; Dry air rated temperature , its significance and use; Concept, introduction and working principle of Non-conventional refrigeration systems. Refrigeration Application : Refrigeration for preservation of Food, Refrigerating systems for transport by trucks and containers; Refrigerated cars; Marine Refrigeration;

Reference Books :

1. R.J.Dossat, Principles of Refrigeration, Pearson Education Asia
2. C.P.Arora, Refrigeration and Air-conditioning, Tata McGraw-Hill
3. Stoecker & Jones, Refrigeration and Air-conditioning
4. J.L.Threlkeld, Thermal Environmental Engineering, Prentice Hall
5. W.F.Stoecker, Industrial Refrigeration Handbook. McGraw-Hill
6. John A. Corinchock, Technician's to Guide to Refrigeration systems, Mc-Graw-Hill
7. P.C.Koelet, industrial Refrigeration; Principles, Design and Application, Macmilan
8. ASHARE HANDBOOKS (i)_ Fundamentals (ii) Refrigeration

2. I.C. ENGINE-I

Teaching Scheme : 4 hrs/week

Examination Paper : 100 Marks
Paper Duration : 3 hrs.

I. **Fuels:** Suitability of fuels for S.I. Engines, Fuel ratings, fuel additives. Alternative fuels: Alcohols, hydrogen, LPG, CNG, Gaseous fuels.

II. **Fuel supply systems**, Carburetion, fuel supply system requirements, Design of fuel supply systems for low emissions, MPFI, electronic controls,

III. **Theory of combustion**: Working process, stages of combustion, heat release rates calculations, flame front propagation, rate of pressure rise, p-q diagram, abnormal combustions, S.I. engine cycle calculations, Combustion Chambers: Requirement of C.C. for S.I. engines and combustion chambers for MPFI, Design Considerations for Combustion Chambers.

IV. **Emissions:** Theory of emission formation, causes and control, emission norms, emissions control by engine modifications, emission after treatment, exhaust system devices, catalytic converters, thermal reactors, Emissions from engines operating on Alternative fuels.

V. **Performance Characteristics**: Variables affecting performance of S.I. engines, methods of performance improvement, effect of altitude and ambient conditions on engine performance parameters. Analytical method of performance estimation, supercharging.

VI. **Modern Engine Technologies**, Mean Value S.I. Engine Modeling, Variable Cam Timing Engine, Multi-Fuel SI Engine.

Reference Books :

1. Internal Combustion Engine Fundamentals, John B. Heywood, First Edition, McGraw Hill, ISBN-13 9780070286375.
2. Engineering Fundamentals of the Internal Combustion Engine, Willard W. Pulkrabek, Second Edition, ISBN-10: 0131405705.
3. Internal Combustion Engines, V. Ganesan, Tata McGraw Hill, Second Edition, 978-0-07-049457-2.
4. Internal Combustion Engines: Applied Thermo-sciences**,** Colin R. Ferguson & Allan T. Kirkpatrick, Second Edition, ISBN: 978-0-471-35617-2

3. Experimental Techniques and Instrumentation in Thermal & Heat power Engineering

Teaching Scheme : 4 hrs/week

Examination Paper : 100 Marks
Paper Duration : 3 hrs.

I. Description Planning of experiments: preliminary, intermediate and final stages in experimental investigations. Steady state and transient techniques. Selection of measuring devices based on static, dynamic characteristics and allowable uncertainties, basics of TAGUCHI method for design of experiments

II. Analysis of experimental data and determination of overall uncertainties in experimental investigation, Calibration of temperature measuring devices, uncertainties in measurement of temperature under various conditions

III. Optical and radiation methods of temperature measurement. Steady state and transient methods of measuring heat fluxes. Measurement of thermal radiation and associated parameters

IV. Calibration of pressure and vacuum measuring devices. Estimation of uncertainties in measurements of pressure and vacuum, Calibration of flow and velocity measuring devices. Uncertainties in measurement under various conditions.

Measurement of turbulence, hot wire/film anemometers, Measurement of thermophysical properties

V. Data logging and acquisition, intelligent instruments and their use, Basics of P, PI, PID controllers, pneumatic and hydraulic controllers, electronic controllers, applications to machine tools, furnaces, material handling etc

Reference Books :

1. Prebrashensky V, Measurements and Instrumentation in Heat Engineering,Vol. 1 and 2, MIR Publishers, 1980
2. Raman C S, Sharma G R, Mani V S N, Instrumentation Devices and Systems, TMH, New Delhi,1983
3. E.O. Doebelin "Measurement systems, Application and Design", McGraw-Hill 1990
4. J.P. Holman "Experimental Methods for Engineers", McGraw-Hill, 1994
5. E.R.G. Eckert and Goldsteen "Measurement Techniques in Heat Transfer", Technovision, 1970

ELECTIVE – I

4. ENVIRONMENTAL ENGINEERING & POLLUTION CONTROL

Teaching Scheme : 4 hrs/week

Examination Paper : 100 Marks
Paper Duration : 3 hrs

I. **Air Pollution** Natural and anthropogenic sources of pollution, Primary and Secondary pollutants, Transport and diffusion of pollutants, Gas laws governing the behavior of pollutants in the atmosphere, air sampling methods, Methods of monitoring and control of air pollutants SO_2, NO_2, CO, SPM.

II. **Water Pollution :**Types sources and consequences of water pollution, Physico-chemical and bacteriological sampling and analysis of water quality . standard sewage and waste water treatment and recycling, ASP/STP. Water quality standard, treatment, utilization and disposal of sludge, Government norms

III. **Land Pollution :** Sources and classification of land pollutants, Industrial waste effluents and heavy metals, their interactions with soil components, degradation of different insecticides, fungicides and weedicides in soil. Solid waste management, process and equipments for energy recovery from municipal solid waste and industrial wste, MSW Act 2000.

IV. **Other sources of pollution :** Noise : Sources of noise pollution, measurement of noise and indices, exposure levels and standards, Noise control and abatement measures, Impact of noise on human health. Marine : Sources and nature pollutnats, oil pollution, metallic pollultants, status of coastal and estuarine pollution in India. Chemicals and drugs from oceans, sea level rise, cause, effect and control Radiation : Introduction, types of radiation and radioactivity, sources and effects.

V. **Pollution from power generation :** Pollution from poewr generation points-thermal power plant, Control measures to reduce them. Environmental considerations in cogeneration and waste heat recovery

VI. Effects of pollutants on human beings, plants, animals, materials and on climate, Acid Rain, Ambient Air Quality Standards, Air Pollution control methods and equipment.

Reference Books :

1. Rao & Rao, Air Pollution.
2. C J Rao, Environmental engineering, New Age Publishers.
3. G. Masters, Introduction to Environmental Engg & Science, Prentice Hall
4. H S Peavy, D R Rowe, G Tchnobanoglous, Environmental Engg, McGraw Hill
5. DeNevers Noel, Air Pollution control Engg. McGraw Hill.
6. Metcalf & Eddy, Waste Water Engg : treatemtent & reuse, McGraw Hill

ADVANCED HEAT TRANSFER - II

Teaching Scheme : 4 hrs/week

Examination Paper : 100 Marks
Paper Duration : 3 hrs.

I. Introduction to heat transfer by convection, a review of viscous, flow, conservation of mass and momentum equations and Navier Strokes equation, energy equation, derivation of energy equation.

II. **Boundary Layer Theory:** Boundary layer equation, Momentum integral methods, laminar layer over a flat plate. Boundary layer equation, Boundary layer approximations, Laminar and Turbulent External Boundary layers with effects of Pressure Gradient, Wall thermal conditions, Viscous dissipation.

III. **Free Convection :** Boundary layer over vertical flat plate and cylinder-series and similarly solution. Free convection inside curved bodies and between parallel plates. Free convection inside curved bodies and between parallel plates. Free convection over heated horizontal plate.

External Flows : Thermal boundary layer, Prandtl and high Prandtl number approximations. Thermal boundary layer over isothermal and adiabatic flat plate and wedge. Heat transfer from curved surfaces.

IV. **Internal Flows :** Heat transfer in a parallel flow over a flat surface, analogy between momentum and heat transfer in turbulent flow, heat transfer in parallel flow and cross flow over a cylinder, heat transfer in parallel flow over a sphere, heat transfer for impinging jets, forced convection in internal flows, Steady forced convection in Couette flow, Poiseuille, plane Poiseuille flow and Leveque solution, Graetz problem.

V. **Turbulent Flow :** Turbulent flows, laminar-turbulent transition, Universal las-of the Wall for smooth and rough surfaces, mixing-length theory and 2-equation models. Turbulence Modeling, Convective heat transfer thorugh porous media.

VI **Condensation, Boiling and heat pipe :** Heat transfer coefficient during condensation on tube bank Simplified relations for boiling heat transfer with water, transpiration cooling, and ablation; classification, construction and application of heat pipe.

Reference Books :

1. Kays W M and Crawford M.E., “Convective Hear and mass transfer”, McGraw Hill Int Edition, 3rd edition, 1993.
2. Spalding D.B., “ Introduction to Convective Mass Transfer”, McGraw Hill, 1963.
3. Bird R.B., Stewart W.E. and Lightfoot E.N., “ Transport Phenomena”, John Wiley and sons, Inc, 1960.
4. Schilchting H. “ Boundary Layer Theory”, Sixth edition,McGraw Hill, 1968.
5. Bejan, Convective Heat Transfer, Wiley, Third Edition, 2004.
6. Patric H, Oostuizen, David Naylor, “Convective Heat Transfer analysis”, McGraw Hill, inc.(1999).

ENERGY CONSERVATION – II

Teaching Scheme : 4 hrs/week

Examination Paper : 100 Marks
Paper Duration : 3 hrs.

I. Potential of renewable energy sources, renewable electricity and key elements, Global climate change, CO_2 reduction potential of renewable energy

II. **Solar Energy :**Solar thermal power plant (Concentrators, solar chimney etc.) Solar thermal conversion devices, Economics and social considerations of component selection. Solar photovoltaic power plants, photovoltaic technology, Design of a photovoltaic system, economics and costing, Application as a distributed power supply strategy

III. **Wind Energy :** Wind energy potential measurement, wind electric generator component design, economics and demand side management, energy wheeling and energy banking concepts.

IV. **Biogas :** properties of biogas (Calorific value and composition), biogas plant technology and status.

V. **Other plants** : Fuel cell based power plants, tidal and wave energy plant design, OTEC Power plants.Geothermal energy : hot springs and steam ejection site selection. Power plants, and economics.

VI. Environmental impacts, Economic and social considerations, Financing mechanisms, Carbon credits, clean development mechanisms.

Reference Books :

1. S.P.Sukhatme, Solar Energy – Principles of thermal collection and storage, II edition, Tata McGraw Hill, New Delhi, 1996.
2. J.A.Duffie and W.A.Beckman, Solar engineering of Thermal processes, II edition, John Wiley, New York, 1991.
3. D.Y.Goswami, F. Kerith and J.F.Krediar, Principles of Solar Engineering, Taylor and Francis.
4. D.D.Hall and R.P.Grover, Biomass Regenerable Energy, John Wiley, New York, 1987.
5. Mukund R. Patel, Wind and Solar Power Systems. CRC Press, 1999.
6. J.F. Manwell, J.C.McGowan, A.L.Rogers, Wind Energy Explained : Theory, Design and Application, John Wiley and Sons, May 2002.
7. R.D.Begamudre, Energy Conversion Systems, New Age International (P) Ltd, Publishers, New Delhi, 2000.

DESIGN OF HEAT EXCHANGER

Teaching Scheme : 4 hrs/week

Examination Paper : 100 Marks
Paper Duration : 3 hrs

I. Constructional Details and Heat Transfer : Types – Shell and Tube Heat Exchangers- Regenerators and Recuperators -Industrial Applications Temperature Distribution and its Implicationos – LMTD – Effectiveness

II. Flow Distribution and Stress Analysis : Effect of Turbulance – Friction Factor – Pressure Loss – Channel Divergence Stresses in Tubes – Heater sheets and Pressure Vessels – Thermal Stresses – Shear Stresses – Types of Failures

III. Design Aspects : Heat Transfer and Pressure Loss – Flow Configuration – Effect of Baffles – Effect of Derivations from ideality – Design of Typical Liquid – Gas – Gas – Liquid Heat Exchangers

IV. Condensers and Evaporators Design : Design of Surface and Evaporative Condensers – Design of Shell and Tube – Plate Type Evaporators

V. Cooling Towers : Packing – Spray Design – Selection of Pumps – Fans and pipes – Testing and Maintenance, Compact cooling towers

VI. Design of special Purpose Heat Exchangers : Corrosive Environment. Marine/space applications, compact heat exchanger

Laboratory Practice(Term Work) - Solve eight assignments based on each of the above mentioned unit

Reference Books :

1. Shah R.K. Sekulic D.P., Fundamental of Heat Exchanger Design, John Wiley, 2003
2. Kakac Sadik, Liu hongtan, Heat exchangers : Selection, rating and thermal design, 2nd Edition, CRC Press, 2002
3. T. Tabrock, G.F. Hewit and N.Afgan, Heat Exchangers, Theory and Practice, McGraw Hill Book Co. 1980.
4. Walker, Industrial Heat Exchangers – A Basic Guide, McGraw Hill Book Co. 1980
5. Nicholas Chermisioff, Cooling Tower, Ann Arbor Science Pub 1981
6. Arttur P. Fraas, Heat Exchanger Design, John Wiley & Sons, 1988

COMPUTATIONAL FLUID DYNAMICS

Teaching Scheme : 4 hrs/week

Examination Paper : 100 Marks
Paper Duration : 3 hrs.

I. Definition and overview of CFD. Advantages and application. CFD methodology.

II. **Governing Differential Equations** : Governing equations for mass, momentum and energy: Navier-Stokes equations; Mathematical behavior of PDE's viz. parabolic, elliptic and hyperbolic, Initial and boundary conditions, Initial and Boundary value problems.

III. **Discretization Techniques :** Introduction to Finite difference Method, Finite Volume method and Finite Element method Finite difference methods. Finite difference repreentaion of PDE's : Solutions to Finite Difference Equations; Implicit, semi-implicit and explicit methods; Errors and stability criteria.

IV. **Finite Volume Methods** : FVM solutions to steady one, two and three dimensional diffusion problems and unsteady one and two dimensional diffusion problems-one and two dimensional, steady and unsteady; Advection schemes, Pressure velocity coupling; SIMPLE family of algorithms.

V. **Grid Generation** : Structured and Unstructured Grids; General transformation of the equations; body fitted coordinate systems; Algebraic and Elliptic Methods; multi block structured grids; adaptive grids.

VI. **Turbulence Modeling :** Effect of turbulence on governing equations; RANS,LES and DNS Models.

Reference Books :

1. Muralidhar. K., Sundarrajan. T.," Computational fluid flow and heat transfer", Naros Publishing House, New Delhi 1995.
2. Ghosdhasdidar, P.S., " Computer simulation of flow and heat transfer", Tata McGraw-Hill Publishing House Ltd., 1998.
3. Subas, V.Patankar,"Numerical heat transfer fluid flow", Hemisphere publishing Corporation.
4. Taylor, C and Hughes J.B., Finite Element Programming of the Navier Stokes Equation, Pineridge Press Ltd. U.K. 1981.
5. Andreson, D.A., Tannehill, I.I., and Pletcher, R.H., Computational fluid Mechanics and Heat Transfer, Hemisphere Publishing Corporation, New York, USA, 1984.
6. Fletcher, C.A.J."Computational Techniques for Fluid Dynamics" Fundamental and General Techniques, Springer-Verlag. 1987

ELECTIVE - II
1. CRYOGENIC ENGINEERING

Teaching Scheme : 4 hrs/week

Examination Paper : 100 Marks
Paper Duration : 3 hrs

I. Introduction : Basic thermodynamics applied to liquidification and refrigeration process, isothermal, adiabatic and joule Thompson expansion process, adiabatic demagnetization, low temperature properties of engineering material, properties of cryogenic fluids.

II. Liquification cycles : Carnot liquification cycle, Figure of Merit and yield of liquification cycles, Inversion curve, Joule Thompson effect

III. LindeHampson cycle, precooled LindeHampson cycle, claudes cycle, Dual cycle

IV. Gas Liquification systems : Helium refrigerated hydrogen liquification systems. Critical components in liquification systems, Binary mixtures, T-C and H-C diagrams, Principles of rectification, Rectification column analysis, McCabe Thiele method, Adsorption system for purification

V. Cryogenic Refrigerators : J T cryocooler, Stirling cycle refrigerators, G M Cryocoolers, Pulse Tube Refrigerators, Regenerators used in cryogenic refrigerators, Magnetic refrigerators, Cryogenic Dewar Construction an design, Cryogenic Transfer Lines, Insulations used in Cryogenic systems.

VI. Measurement and Application of Cryogenics : Different types of vaccum pumps, Instrumentation to measure flow, level and temperature, Application of cryogenics in space programs, Superconductivity, Cryo Metallurgy, Medical and biological applications

Reference Books :

1. Klaus D. Timmerhause and Thomas M Flynn, Cryogenic Process Engineering, Plenum Press, New York 1989.
2. Randall F Barron, Cryogenic Systems, McGraw Hill, 1985
3. Scott R.B. Cryogenic Engineering, van Nostrand and Co. 1962
4. Hearld Weinstock, Cryogenic Technology, 1969

2. ADVANCED AIR CONDITIONING SYSTEMS

Teaching Scheme : 4 hrs/week

Examination Paper : 100 Marks
Paper Duration : 3 hrs

I. Applied Psychrometry, Psychrometric process using chart
Load Estimation : solar heat gain, study of various sources of the internal and external heat gains, heat losses, etc. Methods of heat load calculations : Equivalent Temperature Difference Method, Cooling Load Temperature Difference, and Radiance Method, RSHF, GSHF, ESHF, etc. Inside and outside design condtions.

II. **Air Distribution :** Fundamentals of air flow in ducts, pressure drop calculations, design ducts by velocity reduction method, equal friction method and static regain method, duct materials and properties, insulating materials, types of grills, diffusers, wall registers, etc. VAV.
Sound Control : Definitions of various terms like level, pitch, attenuation, frequency, sources of noise in air conditioning plants, design procedure for noise prevention, noise and vibration study and elimination techniques (description only)

III. **Ventilation and Infiltration:** Requirement of ventilation air, various sources of infiltration air, ventilation and infiltration as a part of cooling load. **Fans and Blowers:** Types, performance characteristics, series and parallel arrangement, selection procedure.
Direct and Indirect Evaporative Cooling: Basic pyschometric of evaporative cooling, types of evaporative coolers, design calculations, indirect evaporative cooling for tropical countries.

IV. **Air Conditioning Equipments and Controls:** Chillers, Condensing units, Cooling coils, bypass factors, humidifiers, various types of fillers, air washers, thermostat, humidistat, cycling and sequence controls, modern control of parity, odour and bacteria, Air filtration- Study of different types of filters, BMS applications, Cooling Towers.

V. **Air conditioning system :** Classification, design of central and unitary systems, typical air conditioning systems such as automobile, air plane, ships, railway coach air-conditioning, warm air system, hot water systems, heat pump, clean rooms (descriptive treatment only). VRF.

VI. **Standards and Codes :** ASHARE.ARI, BIS standards study and interpretation, ECBC, NBC codes

Reference Books :

1. ASHARE Handbooks
2. ISHARE Handbook.
3. Handbook of Air Conditioning System Design, Carrier Incorporation McGraw Hill Book Co. USA.
4. Trane air conditioning manual.
5. Refrigeration and Air conditioning, ARI Prentice Hall, New Delhi.
6. Norman C. Harris, Modern Air conditioning
7. Jones W.P., Air conditioning Engineering, Edward Arnold Publishers Ltd. London, 1984.
8. Jones W.P., Air conditioning Engineering – Applications, Edward Arnold Publishers Ltd, London, 1984.
9. Hainer R.W., Control System for Heating, Ventilation and Air Conditioning, Van Nastrand Reinhold Co. New York, 1984.
10. Refrigeration and Air conditioning – C P Arora, Tata McGraw Hill Publication, New Delhi.
11. McQuiston, Faye; Parker, Jearld; Spitler, Jeffrey 2000, Heating Ventilating and Air conditioning – Analysis and Design, 5th edition, John Wiley & Sons.

3. I.C. ENGINES -II

Teaching Scheme : 4 hrs/week

Examination Paper : 100 Marks
Paper Duration : 3 hrs.

I. **Fuels :** Suitability of fuels for C.I. Engines; Rating of fuels, fuel additives, Alternative fuels: Alternative fuels such as alcohols, CNG, LPG, Bio-diesel, and Biomass fuels, Dual-fuel Engines.
Fuel Supply Systems : Injection, injection design and injection process, and common Rail Fuel injection.

II. **Theory of Combustion:** Stages of Combustion, factors affecting delay period, abnormal combustion, cycle simulation, models for C.I. Engine combustion calculation.
Combustion Chambers: Chamber design, matching with fuel injection, selection criteria of combustion chambers, Induction and exhaust systems, Design of combustion chamber, geometry for CI engines.

III. **Emissions :** Mechanism of formation, Emission norms, strategies of emission control, EGR; Adverse effects of emissions on human health and Environment.

IV. **Performance Characteristics :** Variables affecting performance of CI engines, method of performance improvement, Analytical method of performance estimation.

V. **Turbocharging :** Types, methods and effects, other waste heat utilization practices, EGR, VGT systems, Mathematical model of a turbo-charged diesel engine.

VI. **Advance Engine Technologies :** VCT, Microprocessor controls in engines, low heat rejection engines.

Reference Books :

1. Fundamentals of I.C. Engines – J.B.Heywood, McGrawHill, 2003.
2. Internal-Combustion Engines; V.L.Maleev, Theory and Design, 2nd edition, New York; McGraw-Hill Book Company, New York, 2006.
3. Internal Combustion Engines-R.S.Benson (Vol. I & Vol.II)
4. The Internal Combustion Engine in Theory and practice, Charles Fayette Taylor, 2nd edition, The M.I.T.Press., 2002, Volume I & II.

4. ADVANCED FLUID MECHANICS

Teaching Scheme : 4 hrs/week

Examination Paper : 100 Marks
Paper Duration : 3 hrs.

I. Governing Equations: Mass conservation in differential and integral forms, Flow kinematics, and Momentum equation: substantial derivative, differential and integral form, stress tensor, stress strain relations, Ideal fluid flow concepts.

II. Navier – Stokes Equations: Special forms: Euler equations, Bernoulli equation, stream function, vorticity. Exact solutions: fully developed flow in channel, pipe, flow between concentric rotating cylinders, Couette flow, Stokes first problem (unsteady flow), creeping flow past a sphere, cylinder.

III. Boundary Layers: Boundary layer assumptions, equations, flow over a flat plate, similarity (Blasius) solution, Falkner-Skan equation, momentum integral method, external flows: drag, lift, flow separation.

IV. Turbulent flow: Introduction to hydrodynamic stability, characteristics of turbulence , governing equations, turbulent boundary layer, algebraic models (Prandtl's mixing length), velocity profile over a flat plate and in pipes.

V. Turbulent Shear flows: Equations for free shear layers: mixing layer, plane and axis symmetric jet, wake. Turbulent energy equation, two equation model (k-epsilon), Large Eddy simulation, various turbulent models.

VI. Compressible flow: One dimensional flow: speed of sound, variable cross –section flow, converging, diverging nozzle, effect of friction and heat transfer, normal shock relations, introduction to oblique shocks, two dimensional flows (subsonic and supersonic) past slender bodies, compressible boundary layers.

Reference Books :

1. Advanced Fluid Mechanics, G. Biswas and K. Muralidhar
2. Viscous Fluid Flow, F.M. White
3. Boundary Layer Theory, H. Schlichting
4. Fluid Mechanics, Cengel, Tata Mc Graw Hill
5. Fluid Mechanics, F.M. White, Tata Mc Graw Hill Int.