COURSE STRUCTURE FOR M. TECH.
(THERMAL SYSTEM DESIGN)

SEMESTER – I

Code No.	Subject	L	T	P	Exam Scheme				Total	Credits
					Theory		Tuto.	Pract.		
					Hrs.	Marks	Marks	Marks		
ME 603	Advance Heat Transfer	3	0	2	2	100	-	50	150	4
ME 721	Advance Thermodynamics & Combustion	4	0	0	2	100	-	-	100	4
ME 723	Thermal Power Plant Engineering -I	3	0	0	2	100	-	-	100	3
ME 725	Computational Methods in Fluid Flow & Heat Transfer	3	0	0	2	100	-	-	100	3
ME 727	Software Practice	0	0	4	-	-	-	100	100	2
	Elective – I	3	0	0	2	100	-	-	100	3
ME 650 **ME 729** **ME 731**	Optimization Techniques. Residual Life Assessment of Boiler Plant Equipments Analysis & Design of I.C. Engines									

SEMESTER – II

Code No.	Subject	L	T	P	Exam Scheme				Total	Credits
					Theory		Tuto.	Pract.		
					Hrs.	Marks	Marks	Marks		
ME 682	Design of heat exchangers	3	0	2	2	100	-	50	150	4
ME 722	Exergy analysis of Thermal Systems	4	0	0	2	100	-	-	100	4
ME 726	Design of Refrigeration & Air-conditioning systems	3	0	2	2	100	-	50	150	4
ME 724	Thermal Power plant Engineering – II	3	0	0	2	100	-	-	100	3
ME 728	Laboratory Practice	0	0	2	2	-	-	50	50	1
	Elective – II	3	0	0	2	100	-	-	100	3
ME 732 **ME 734** **ME 736**	Non-conventional Energy Systems Analysis & Design of Thermal Turbomachines Theory & Design of Cryogenic Systems									

SEMESTER – III

Code No.	Subject	L	T	P	Exam Scheme				Total	Credits
					Theory		Tuto.	Pract.		
					Hrs.	Marks	Marks	Marks		
ME 801	Dissertation Preliminaries	0	0	16	-	-	-	400	400	8
ME 803	Seminar	0	0	4	-	-	-	100	100	2

SEMESTER - IV

Code No.	Subject	L	T	P	Exam Scheme				Total	Credits
					Theory		Tuto.	Pract.		
					Hrs.	Marks	Marks	Marks		
ME 802	Dissertation	0	0	24	-	-	-	600	600	12

M. Tech (THERMAL SYSTEM DESIGN), Semester - I	L	T	P	C
ME 603 : Advance Heat Transfer	**3**	**0**	**2**	**4**

- Modes of heat transfer. **(02 Hours)**

- Conduction, Factors affecting thermal conductivity of solids, liquids & gases, General three , dimensional heat conduction equation in Cartesian, Cylindrical & spherical coordinates, Initial condition and various boundary conditions. Heat source systems, Critical thickness of insulation. Different types of fins & their analysis, Two -dimensional steady state conduction. Electrical analogy, Graphical & numerical methods. Transient heat conduction with & without temperature gradients within the system, Heat flow in semi infinite solids. Application of Heisler charts. **(12 Hours)**

- Free & forced convection, Similarity & simulation of convection heat transfer, Boundary layer theory. Turbulent flow heat transfer. Analogy between momentum & heat transfer. Heat transfer with liquid metals. Heat transfer in high velocity flow. Recent development s in the theory of turbulent heat transfer. Natural convection under different situations. Empirical relations in convection heat transfer. **(14 Hours)**

- Boiling & condensation. **(03 Hours)**

- Regimes of boiling heat transfer. Heat transfer in condensation. Drop wise & film condensation. Empirical equations. **(02 Hours)**

- Radiation heat transfer properties. Laws of thermal radiation. Shape factors. Radiation heat transfer between black, diffuse & gray surface. Electric al network method of solving radiation problems. Radiosity approach. Gas emission & absorption, Bulk radiations. **(12 Hours)**

(Total Lecture Hours: 45)

PRACTICALS:

1. Calibration of thermocouple
2. Heat transfer in natural convection
3. Heat transfer in forced convection
4. Thermal conductivity of insulating pow der
5. Heat transfer from pin fin apparatus
6. Heat transfer through composite wall

BOOKS RECOMMENDED:

1. J.P.Holman, “Heat Transfer”, McGraw Hill Book Co. Special Indian 9th Edition, 2008
2. Oziski, M. N. “Heat Transfer – A Basic Approach”, McGraw Hill, N. Y., 2001.
3. Roshenow, W., Hartnett, J., Ganic, P., “Hand Book of Heat Transfer ”, Vol,1 & 2, McGraw Hill, N. Y., 2002.
4. Incropera & Hewitt, “Fundamentals of Heat and Mass Transfer”, John Wiley , 2000.
5. S.P.Sukhatme, “Heat Transfer”, Orient Longman, 2001

M. Tech (THERMAL SYSTEM DESIGN), Semester - I	L	T	P	C
ME 721 : Advance Thermodynamics & Combustion	**4**	**0**	**0**	**4**

- Review of fundamentals – availability, Entropy, Carnot theory, Entropy of the ideal gas, TS diagram, Entropy and reversibility, Entropy and irreversibility, Irreversible part of the second law, Heat and entropy in irreversible processes, Entropy and Non equilibrium states, Principle of increase of entropy, Application of the entropy principle, Entropy and disorder, Exact differentials. **(06 Hours)**

- Chemical thermodynamics and flame temperatures, Heat of reaction and formation, Free Energy and equilibrium constants, Flame temperatures and equilibrium composition. **(07 Hours)**

- Chemical kinetics, Order of reaction, Rate of reactions, Simulations independent and chain reactions, Pseudo – First order reactions, Partial equilibrium, Pressure and temperature effects. **(07 Hours)**

- Explosive and oxidative characteristics of fuels, Criteria for explosion, Explosion limits and oxidation of hydrogen, Carbon monoxide and hydrocarbons. **(07 Hours)**

- Premixed flames, Laminar flame structure, Laminar flame speed, Flame speed measurements, Stability limits of laminar flames, Turbulent flames, The turbulent flame speed, Flame stabilization in turbulent flows. **(08 Hours)**

- Diffusion flames, Gaseous fuel tests, Turbulent fuel tests, Burning of condensed phases, Droplet combustion. **(05 Hours)**

- Modeling of coal combustion and emissions shrinking core model, Theory of formation of NO_x, CO_2, SO_x and particulate emissions. **(05 Hours)**

(Total Lecture Hours : 45)

BOOKS RECOMMENDED:

1. S. P. Sharma and Mohan C., "Fuels & Combustion", McGraw-Hill-2007.
2. Irvin Glassman, "Combustion", 2nd Edition, Academic Press, Inc. Harcourt Brace Jovanorich Pub., Orlando, 2002.
3. Strehlow, R. A., "Combustion Fundamentals", McGraw Hill Book Co., N. Y., 2002.
4. Phil Attard, "Thermodynamics and Statistical Mechanics", Australian Research Council, University of South Australia, 2002.
5. Mark W. Zemansky and Richard H. Dittman, "Heat and Thermodynamics", McGraw -Hill International Editions, 7th Edition, 2003.

M. Tech (THERMAL SYSTEM DESIGN), Semester - I	**L**	**T**	**P**	**C**
ME 723 : Thermal Power Plant Engineering-I	**3**	**0**	**0**	**3**

- Classification of boilers, Description of boilers, Boiler specifications, Natural circulation boilers and forced circulation for sub-critical and supercritical boilers. **(08 Hours)**
- Types of fuels, Fuel preparation for coal fired boilers, Features of boiler furnaces, coal fired, Gas fired, Oil fired, Pulverized fuel. **(07 Hours)**
- Fluidized bed combustion chambers, Burners, Combustion calculations, Economizers, Air-preheaters, Superheaters, De-superheaters, Re-heaters. **(10 Hours)**
- Forced and induced draft fans and blowers, Boiler feed pumps, Steps for boiler design, Steam system materials, Heat balance sheet, Electrostatic precipitators, Cogeneration and combined cycle, Boiler efficiency, Thermodynamics and power plant cycle analysis. **(20 Hours)**

(Total Lecture Hours: 45)

BOOKS RECOMMENDED:

1. Shields, C. D., " Boilers", McGraw Hill, New York, 2001
2. Babcock-Wilcox manual " Steam"
3. Vandagriff, R.L "Practical guide to boiler systems", Marcel Dekker, 2000
4. Oliver, K.G "Industrial boiler management, an operations guide, Industri al Press, New York. 2002
5. El Wakil M. M., "Power Plant Technology", McGraw-Hill, 2001.

M. Tech (THERMAL SYSTEM DESIGN), Semester -I	L	T	P	C
ME 725 : Computational Methods in Fluid Flow & Heat Transfer	3	0	0	3

- **REVIEW OF GOVERNING EQUATIONS CONNECTIVE FLUID FLOW AND HEAT TRANSFER**
  Conservation of mass, Newton's second law of motion, Expanded forms of Navier-Stokes equations, Conservation of energy principle, Special forms of the Navier-Stokes equations, Classification of second order partial differential equations, Initial and boundary conditions, Governing equations in generalized coordinates. **(08 Hours)**

- **FINITE DIFFERENCE, DISCRETIZATISON, CONSISTENCY, STABILITY AND FUNDAMENTAL OF FLUID FLOW MODELING**
  Elementary finite difference quotients, Basic aspects of finite difference equations, Errors and stability analysis, Some nontrivial problems with discretized equations, Applications to heat conduction and convection. **(10 Hours)**

- **SOLUTIONS OF VISCOUS INCOMPRESSIBLE FLOWS BY STREAM FUNCTION , VORTICITY FORMULATION**
  Two dimensional incompressible viscous flow, Incorporation of upwind scheme, Estimation of discretization error, Application to curvilinear geometries, Derivation of surface pressure and drag.
  (07 Hours)

- **SOLUTION OF NAVIER-STOKES EQUATIONS FOR INCOMPRESSIBLE FLOWS USING MAC AND SIMPLE ALGORITHMS**
  Staggered grid, Solution of the unsteady Navier-Stokes equations, Solutions of energy equation, Formulation of the flow problems, Simple algorithm. **(06 Hours)**

- **INTRODUCTION TO FINITE VOLUME METHOD** **(07 Hours)**
  Integral approach, discretization & higher order schemes, Application to complex geometry.

- **INTRODUCTION TO FINITE ELEMENT METHOD** **(07 Hours)**
  Stiffness matrix, Isoparametric elements, Formulation of finite elements for flow and heat transfer problems.

(Total Lecture Hours : 45)

BOOKS RECOMMENDED:

1. Anderson D.A., Tannehill J.C., Pletcher R.H., "Computational Fluid Mechanics and Heat Transfer", Hemisphere Publishing Corporation, New York, U.S.A. 2004.
2. Ankar S.V., "Numerical Heat Transfer and Flow" Hemisphere Publ., Corporation, 2001.
3. H.K.Versteag and W.Malalsekara, "An Introduction to Computational Fluid Dynamics", Longman, 2000.
4. Carnahan B., "Applied Numerical Methods", John Wiley & Sons 2001.
5. Patankar, "Numerical heat transfer and fluid flow", McGraw-Hill, 2002.

M. Tech (THERMAL SYSTEM DESIGN), Semester - I	L	T	P	C
ME 727 : Software Practice	**0**	**0**	**4**	**2**

- Generation velocity profile for laminar flow
- Generation of velocity profile for turbulent flow
- Friction factor for laminar flow
- Friction factor for turbulent flow
- Shear stress distribution for a flow in horizontal duct
- Nussent number determination for a flow with constant it edition
- Nussent number determination for a flow with heat edition at constant temperature
- Determination of drag for a flow over a body
- Analysis of 2-D transient heat flow over a plate

M. Tech (THERMAL SYSTEM DESIGN), Semester – I, Elective-I	L	T	P	C
ME 650 : Optimization Techniques	**3**	**0**	**0**	**3**

- Single and multivariable optimization methods, constrained optimization methods, Kuhn, tucker conditions, necessary & Sufficiency theorems. **(10 Hours)**
- Linear programming, Traveling salesman problem and transshipment problems, Post optimization analysis. **(10 Hours)**
- Integer programming all integer, Mixed integer and zero, one programming **(08 Hours)**
- Geometric programming – concept – degree of difficulty – solution of unconstrained & constrained non linear problems by geometric programming. **(09 Hours)**
- Dynamic programming. **(08 Hours)**

(Total Lecture Hours : 45)

BOOKS RECOMMENDED:

1. Rao S.S., “Optimization Theory & Applicatio ns”, Wiley Eastern 2000.
2. Deb. K, “Optimization for Engineering Design”, Prentice Hall of India, 2002
3. Reklaitis G.V., Ravindram A., Ragsdell K.M., “En gineering Optimization Met hods & Application”, Wiley, 2001.
4. Verma, A. P,. “Operatin Research”, S. K. Kataria and Sons, 2007.
5. Vora, N. D, “Quantitative techniques”, Tata -McGraw-Hill, 2006.

M. Tech (THERMAL SYSTEM DESIGN), Semester – I, Elective- I	L	T	P	C
ME 729 : Residual Life Assessment of Boiler	**3**	**0**	**0**	**3**

- General approval to the analysis of metallurgical objective of failure analysis , Factors related to failures, Stages of analysis, Collection of back ground data & selection of sample.
  (08 Hours)

- **METAL FATIGUES** **(07 Hours)**
  Fatigue failure life, Cause & prevention of fatigues failures.

- **CORROSION RELATED FAILURES** **(07 Hours)**
  Introduction to corrosion, Types of corrosions, Environmental factors, Preventive measures.

- **ELEVATED TEMPERATURE FAILURE** : **(07 Hours)**
  Creep, Elevated temperature fatigue, Thermal fatigue prevention.

- **RESIDUAL STRESSES** **(08 Hours)**
  Thermal residual stresses, Metallurgical residual stresses, Mechanical residual stresses, Chemical effects on residual stress.

- Remaining Life Assessment (RLA) of critical components relevance of RLA, RLA methodology, Application of Non Destructive Testing, Risk based inspections, Case study on boiler tube & its accessories failure.
  (08 Hours)

(Total Lecture Hours: 45)

BOOKS RECOMMENDED:

1. Towe, H. C., "Life Extension & Assessment of Fossil Power Plant" , McGraw-Hill, 2005.
2. Webster, G. A., Anisworth, R.A., "High Temperature Component life assessment", McGraw-Hill, 2004.
3. Hozel, Deiter K., "Methods to Extend Mechanical Components life", AIAA Publication, Washington, 2004.
4. Oliver, K.G "Industrial boiler management, an operations guide, Industrial Press, New York. 2002
5. El Wakil M. M., "Power Plant Technology", McGraw-Hill, 2003.

M. Tech (THERMAL SYSTEM DESIGN), Semester – I, Elective-I	L	T	P	C
ME 731 : Analysis & Design of I.C. Engines	3	0	0	3

- Review of thermodynamic cycles – ideal, fuel – air and real cycles **(06 Hours)**
- Engine heat transfer and friction **(06 Hours)**
- Gas exchange processes: flow through valves, phase of the flow, turbulence, analysis of suction and exhaust processes, manifold tuning. **(07 Hours)**
- Analysis of compression and expansion processes. **(06 Hours)**
- Modeling of combustion in s. i. and c. i. engines. **(05 Hours)**
- Digital simulation of complete engine cycle. **(04 Hours)**
- Design of engine components – piston, cylinder, piston rings, connecting rod, crankshaft etc. **(08 Hours)**
- Theory of super chargers / turbo chargers **(03 Hours)**
- Similarity considerations, balancing and vibrations of engines **(04 Hours)**

(Total Lecture Hours: 45)

BOOKS RECOMMENDED:

1. Maleev, "I. C. Engines: Theory and Practice", McGraw -Hill-2000.
2. Heywood, J. B., "Internal Combustion Engine Fundamentals", McGraw Hill International Edition, 2002.
3. Richard, Stone, "Introduction to Internal Combustion Engines", 2nd Edn. McMillan Press, 2003.
4. Taylor, C. F., "Internal Combustion Engine in Theory and Practice", Vol. 1 & 2, M. I. T. Press, Cambridge, USA, 2003.
5. Juvinall, R. C., and Marshek, K. M., "Fundamental of Machine Component Design", John Wiley & Sons, N.Y., 2001.

M. Tech (THERMAL SYSTEM DESIGN), Semester - II	L	T	P	C
ME 722 : Exergy Analysis of Thermal Systems	**4**	**0**	**0**	**4**

- Basic concepts of energy analysis of thermal systems **(05 Hours)**

- Basic exergy concepts: **(10 Hours)**
  Classification of forms of exergy, concepts of exergy, exergy concepts for a control region, physical exergy, chemical exergy, exergy concepts for closed system analysis.

- Elements of plant analysis **(10 Hours)**
  Control mass analysis, Control region analysis, Criteria of performance, Pictorial representation of exergy balance, Exergy based property diagram

- Exergy analysis of processes **(10 Hours)**
  Expansions process, Compression processes, Heat transfer process, Mixing & separation Process, Chemical process including combustion.

- Energy analysis of thermal systems **(10 Hours)**
  Gas turbine plant, Thermal power plant, Cogeneration plant, Captive power plant, Combined cycle power plant, Refrigeration plant, Chemical plant Linde air liquification plant, Heat exchanger.

(Total Lecture Hours : 45)

BOOKS RECOMMENDED:

1. Kotas J.J., "The Exergy Methods of Thermal Plant Analysis", 2nd Ed., Krieger Publ. Corp. U.S.A., 2000.
2. Larry, C.W., Schmidt, P.S., and Schmidt, P.S. and David, R.B., "Industrial Energy Management and Utilization", Hemisphere Pub. Corp., Washington, 2001.
3. Seikan, Ishigai, "Steam Power Engineering, Thermal and Hydraulic Design Principles", Cambridge Univ., Press, 2000.
4. Turner, W.C., (Ed.), "Energy Management Handbook", John Wiley & Sons, N.Y., 2002.
5. Dryden, I.G.C., "The Efficient use of Energy", Butterworths, London, 2000

M. Tech (THERMAL SYSTEM DESIGN), Semester - II	**L**	**T**	**P**	**C**
ME 726 : Design of Refrigeration and Air Conditioning Systems	**3**	**0**	**2**	**4**

- Review of basic principles of refrigeration – Vapour compression and vapour absorption cycles, Ecofriendly refrigerants. **(03 Hours)**
- Low temperature refrigeration, Martinovesky, Dubinsky machine, Capitza air liquifier; Cap phillips machines, Gifford models. **(04 Hours)**
- Refrigerator using solid as working media. **(03 Hours)**
- Magnetic refrigeration systems. **(03 Hours)**
- Design aspects of refrigeration system components. **(04 Hours)**
- Design of water coolers, Ice plant, Cold storage plants. **(03 Hours)**
- Review of air conditioning principles. **(05 Hours)**
- Psychrometry of various air conditioning processes. **(05 Hours)**
- Cooling load calculations for air conditioning systems. **(04 Hours)**
- Design aspects of various components of an air conditioning system such as fans, Cooling coils, Heating coils, Ducts and air, Distribution system. **(04 Hours)**
- Analysis and design of air Washers and cooling towers. **(03 Hours)**
- Design of residential, commercial and industrial air conditioning plants. **(04 Hours)**

(Total Lecture Hours: 45)

PRACTICALS:

1. Performance test on vapour compression refrigeration system using different expansion devices.
2. To determine the c.o.p. of vapour absorption system.
3. Performance test on heat pump.
4. To determine the adiabatic efficiency of an air cooler
5. Performance test on air conditioning plant.
6. To determine the c.o.p. of an ice plant.

BOOKS RECOMMENDED:

1. Stocker, W. F. and Jones, J. W., “Refrigeration and Air Conditioning” , McGraw Hill, N. Y. 1986.
2. Dossat, R. J., “Principles of Refrigeration”, John Wiley and Sons, 1988.
3. Threlked, J.L., “Thermal Environmental Engineering”, Prentice Hall, N. Y. , 1970.
4. Baron, R. F., “Cryogenics Systems”, Oxford Press, USA, 1985.
5. ASHRAE Fundamentals, Applications, Systems and Equipment, 1999.

M. Tech (THERMAL SYSTEM DESIGN), Semester - II	**L**	**T**	**P**	**C**
ME 682 : Design of Heat Exchangers	**3**	**0**	**2**	**4**

- Review of heat transfer principles & convection correlation. **(03 Hours)**
- Introduction to heat exchangers and classification **(03 Hours)**
- Basic design methodologies, Net Transferable Units method and Logarithmic Mean Temperature Deference method **(04 Hours)**
- Design of double pipe heat exchangers **(05 Hours)**
- Shell & tube type heat exchangers, nomenclature, J-factors, conventional design methods, bell, Delware method **(05 Hours)**
- Compact heat exchangers, J-factors, design method **(08 Hours)**
- Condensers classification and design methods for surface condensers **(05 Hours)**
- Evaporators – Classification and design methods **(03 Hours)**
- Plate type – Heat exchangers **(03 Hours)**
- Regenerators **(03 Hours)**
- Furnace design **(03 Hours)**

(Total Lecture Hours: 45)

PRACTICALS:

1. Thermal aspects of heat exchanger design
2. Design of double pipe Heat exchanger
3. Timkers model & TEMA standards
4. Bell Deware's method for shell and tube type heat exchanger design
5. Design of Reboilers and estimation of loss of energy in the pipe
6. Analysis and design regenerative heat exchanger
7. Circulated fludized bed combustion boiler
8. Design of compact heat exchanger
9. Design of plate type heat exchanger
10. Heat exchange networking

BOOKS RECOMMENDED:

1. Saunders, E.A.D., "Heat Exchangers – Selection Design and Construction", Longmann Scientific and Technical, N.Y., 2001.
2. Kays, V.A. and London, A.L., "Compact Heat Exchangers" , McGraw Hill, 2002.
3. Holger Martin, "Heat Exchangers" Hemisphere Publ. Corp. , Washington, 2001.
4. Kuppan, T., "Heat Exchanger Design Handbook", Macel Dekker, Inc., N.Y. , 2000
5. Seikan Ishigai, "Steam Power Engineering, Thermal and Hydraulic Design Principles", Cambridge Univ. Press, 2001.

M. Tech (THERMAL SYSTEM DESIGN), Semester - II	L	T	P	C
ME 724 : Thermal Power Plant Engineering - II	**3**	**0**	**0**	**3**

- Steam turbines, Classification, Compounding of steam Turbines, Arrangements of steam turbines, Governing of steam turbines. **(08 Hours)**
- Steam cycle heat exchangers (Condensers), Concept of heat recovery steam generators, Re-heaters, Regenerative feed heaters – Fans and blowers, Boiler feed pumps, Condensate extraction pumps, Air pumps. **(15 Hours)**
- Circulating water systems, Cooling towers. **(05 Hours)**
- Natural and mechanical draught and their design calculations. **(07 Hours)**
- Energy auditing, Environmental considerations, Ash handling systems, Air pollution control. **(10 Hours)**

(Total Lecture Hours : 45)

BOOKS RECOMMENDED:

1. Black and Vetach, "Power Plant Engineering", Chapman and Hall, International Thomson Publishing Co., 2001.
2. El, Wakil, "Power Plant Technology", McGraw-Hill, 2003.
3. Gebhartt, G. F.,"Steam Power Plant Engineering", John Wiley & Sons, 2002.
4. Kearton, "Steam Turbine Theory and Practice", ELBS, 2001.
5. Burger R., "Cooling Tower Technology", Lilburn, 2004.

M. Tech (THERMAL SYSTEM DESIGN), Semester - II	**L**	**T**	**P**	**C**
ME 728 : Laboratory Practice	**0**	**0**	**2**	**1**

- To determine specific fuel consumption & thermal efficiency of S. I. Engine
- To determine specific fuel consumption & thermal efficiency of C. I. Engine
- To determine Thermal conductivity of Insulating Material
- To determine valve timing diagram of I. C. Engine
- To determine the boiler efficiency
- To study various aspects of thermal power plant

M. Tech (THERMAL SYSTEM DESIGN), Semester – II, Elective - II	**L**	**T**	**P**	**C**
ME 732 : Non-conventional Energy Systems	**3**	**0**	**0**	**3**

- Solar energy, Solar thermal systems, Solar cells, Thermal storage, Solar heating & cooling of buildings, Solar economics. **(12 Hours)**
- Wind energy conversion systems, Scientific chulhas, Biogas plant & their design, Microbiological aspects of biogas generation and alcohol fermentation, Production of liquid fuels, Pyrolysis, gasification. **(10 Hours)**
- Fuel cell technology & hybrid vehicles. **(10 Hours)**
- Hydrogen energy & Its future impact. **(07 Hours)**
- Geothermal energy **(06 Hours)**

(Total Lecture Hours : 45)

BOOKS RECOMMENDED:

1. Duffie, J.A., and Bechman, "W. A., "Solar Engineering of Therm al Processes", John Wiley, N. Y., 2002.
2. Maths, D. A., "Hydrogen Technology for Energy", Noyes Data Corp., 2002.
3. Freris, L. L. "Wind Energy Conversion System", Prentice Hall, 2001.
4. Spera, D.A., "Wind Turbine Technology, Fundamental Concepts of Wind Turbine Engineering", ASME Press. N. Y. 2001.
5. Twidell, J.W., and Weir, A.D., "Renewable Energy Resources", ELBS, 2000.

M. Tech (THERMAL SYSTEM DESIGN), Semester – I, Elective-I	L	T	P	C
ME 734 : Analysis & Design Of Thermal Turbomachines	3	0	0	3

- Design of compressors, Centrifugal compressor, Inlet section, Impeller passages, Effect of impeller blade shape on performance, Impeller channel, Vaneless and vaned diffusers, Effect of mach number, Design procedure. **(07 Hours)**

- Axial flow compressor, stage characteristics, Blading efficiency, Design parameters, Blade loading, Lift coefficient and solidity, Three dimensional flow considerations, Radial equilibrium design approach, Actuator disc theory approach , Design procedure and calculations. **(08 Hours)**

- Design of turbine flow passages, Introduction, Isentropic velocity ratio, Energy distribution in turbines, Effect of carryover velocity on energy distribution. **(06 Hours)**

- Impulse turbine flow passages, Blade pitch and width, Blade height, B lade entrance and exit angles, Geometry of impulse blade profiles, Losses in impulse blade passages, Design procedure for single stage and multistage impulse turbines. **(08 Hours)**

- Reaction turbine flow passages, Reaction blade profiles, Blade angles, Gauging and pitch, Blade width and height, Losses in reaction blade passages, Degree of reaction, design procedure for impulse, reaction turbines, Calculations for axial thrust, Turbines for optimum capacity. **(08 Hours)**

- Flow passage with radial equilibrium, The free vortex turbine, Turbine with constant specific mass flow, Turbines with constant nozzle angle, comparison of radial equilibrium design, off design performance using radial equilibrium theory, Actuator disc theory, Single parameter analysis, Stream line curvature methods. **(08 Hours)**

(Total Lecture Hours : 45)

BOOKS RECOMMENDED:

1. Lee J.E., “Steam & Gas Turbine”, McGraw Hill city, 2001.
2. Shlyakhin P., “Steam Turbines, Theory & Design”, Peace Publications, Moscow, 2000.
3. Frank P. Beleier, “Fan Hand Book Selection”, Application and Design”, Wiley, 2003.
4. Saravanamootoo, H.I.H., & Rogers, G.F.C., “Gas Turbine Theory” , Pearson Pub. Company, Pearson Education (Singapore) Pvt. Ltd., Indian Branch, New Delhi 2001.
5. Dixon, “Theory and thermodynamics of turbomachinery”, Elsevier Science and Technological series, 5th Edition-2005.

M. Tech (THERMAL SYSTEM DESIGN), Semester – II, Elective – II	**L**	**T**	**P**	**C**
ME 736 : Theory & Design of Cryogenic Systems	**3**	**0**	**0**	**3**

- Introduction and application. **(03 Hours)**
- Cryogenics Fluids: Properties of air, Oxygen, Nitrogen, Hydrogen, Helium and its isotopes. **(04 Hours)**
- Cryogenics refrigeration systems : Recuperative & regenerative cycles, Joule Thomson cycle ; Gifford , Mcmohan cycle, Stirling cycle, Pulse Tube refrigeration, Magneto caloric refrigeration, Vuilleumier refrigerator. **(04 Hours)**
- Gas liquefaction systems: Ideal systems, Linde, Linde dual pressure system, Claude, Heylandt, Kapitza systems, Cascade cycle. **(04 Hours)**
- Cryogenic insulation: Vacuum insulation, Multilayer insulation (MLI), Methods of measuring effective thermal conductivity of MLI, Liquid & vapour shield, Evacuated porous insulation, Gas filled powders and fibrous materials, Solid foams. **(03 Hours)**
- Cryogenic instrumentation: Peculiarities of cryogenic strain measurement, Pressure, Flow, Density, Temperature and liquid level measurement for cryogenic application. **(03 Hours)**
- Purification and separation of gases, Liquefied natural gas: Principles of gas separation: Separation by condensation & flashing, Separation by distillation. Air separation system: Linde single column system. Linde double, Column systems etc, Liquefaction of Natural Gas. **(04 Hours)**
- Storage & handling systems: Dewar vessel design, Piping, Support systems, Vessel safety devices and storage systems, Industrial storage systems. **(03 Hours)**
- Transfer systems: Transfer from storage, Un-insulated transfer lines, Insulated lines, Transfer system components. **(04 Hours)**
- Properties and selection of Materials: Study of material properties & their selection for cryogenic application. **(05 Hours)**
- Vacuum Systems, Cryo pumping. **(03 Hours)**
- Equipments for low temperature systems: Heat exchangers, Compressor, Expanders. **(05 Hours)**

(Total Lecture Hours : 45)

BOOKS RECOMMENDED:

1. Hastlden, C., “Cryogenic Fundamentals”, Academic Press, 2001.
2. Barron R., “Cryogenic Systems”, Plenum Press, 2001.
3. Walker, “Cryocoolers”, Vol. 1 & 2, Plenum Press, 2000.
4. Mikulin, Y., “Theory and Design of Cryogenic systems”, MIR Publication, 2002.
5. Barron, R. F., “Cryogenics Systems”, Oxford Press., USA, 2002.