COURSE STRUCTURE FOR M. TECH.
(TURBOMACHINES)

SEMESTER – I

Code No.	Subject	L	T	P	Exam Scheme				Total	Credits
					Theory		Tuto.	Pract.		
					Hrs.	Marks	Marks	Marks		
ME 601	Finite Element Methods	3	0	2	2	100	-	50	150	4
ME 603	Advance Heat Transfer	3	0	2	2	100	-	50	150	4
ME 605	Experimental Techniques	3	0	2	2	100	-	50	150	4
ME 607	Advance Fluid Dynamics	3	0	2	2	100	-	50	150	4
ME 613	Assignments – I (Turbomachines)	0	0	4	2	-	-	100	100	2
	Elective – I	3	0	2	2	100	-	50	150	4
ME 609 **ME 611** **ME 650**	Energy & Exergy Analysis Gas Turbine Cycle & Jet Propulsion Optimization Techniques									

SEMESTER – II

Code No.	Subject	L	T	P	Exam Scheme				Total	Credits
					Theory		Tuto.	Pract.		
					Hrs.	Marks	Marks	Marks		
ME 602	Gas Dynamics and Flow Through Turbo machine Passages	3	0	0	2	100	-	-	100	3
ME 604	Thermal Turbo Machines	3	0	2	2	100	-	50	150	4
ME 606	Hydro Turbo Machines	3	0	2	2	100	-	50	150	4
ME 608	Computational Fluid Dynamics Techniques	3	0	4	2	100	-	100	200	5
ME 616	Assignments-II (Turbomachines)	0	0	4	2	-	-	100	100	2
	Elective – II	3	0	2	2	100	-	50	150	4
ME 612 **ME 614** **ME 682**	Design of Thermal Turbo machine Design of Hydro Turbo machines Design of Heat Exchangers									

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

SEMESTER – I

ME 601	:	Finite Element Methods	L	T	P	Credits
			3	0	2	04

1. Introduction to FEM
2. Formulation Methods – Direct Approach, Variation Approach and Weighted residual Approach.
3. C Deg and C' elements, Isoparametric elements.
4. Interpolation Functions, Element Matrix, Assembly and Boundary Conditions.
5. Condensation and Solution Algorithms.
6. Introduction to non-linear finite element methods
7. Adaptive Finite Analysis, Automatic mech. Generation Estimation, Choice of new Mesh, Transfer Variables.
8. Applications of FEM in Heat Conduction, Fluid Flow, Elastic Plane Stress, Plane Strain and Ax-symmetric problems.

Reference:

1. Huebner, K.H. and Thorton, E.A., "The Finite Element Methods for Engineers" John Wiley & Sons, 1982.
2. Cook, R.D., Malkus, D.S. and Plesha, M.E., "Concepts and Applications of Finite Element Analysis", 3rd Ed., John Wiley & Sons, 1989.
3. Bathe, K.J., "Finite Element Procedures", Prentice Hall of India, New Delhi, 1997.
4. Zienewiccz, O.C. and Taylor, R.L., "The Finite Element Methods", Vol.1 and Vol.2, McGraw Hill, 1991.
5. Belytshko, T., Liu, W.K. and Moran, B., "Non-linear Finite Elements for Continua and Structures", McGraw Hills, 2000.

ME 605	:	Experimental Techniques	L	T	P	Credits
			3	0	2	04

- Basic concepts of Measurement
- Statistical Analysis of Experimental Data Method of Least Squares, Uncertainty Analysis.
- Response characteristics of Instruments – 1st & 2nd order instrument.
- Transducers, Vibration & Noise measurements.
- Theory of strain gauges
- Advance & Specific measurements –Stress & Strain Measurement by Photo Elastic Bench, Hotwire & Laser Doppler Anemometry.
- Thermal & Transport property measurement, T hermo gravimetry, Gas Chromatography, Air Pollution & Nuclear radiation measurement.
- NDT, Radiography, Ultrasonography
- Wind Tunnel Testing
- Data Acquisition System

Reference:

1. Holman, J.P, "Experimental Methods for Engineers" 5th Ed. McGraw hill International Edition, 1989
2. Doeblin, E.O., "Measurement System – Application and Design – McGraw Hill International Ed., 1990
3. Eckman, D.P. "Industrial Instrumentation", Wiley Eastern Ltd., New Delhi, 1990
4. Hale, J. and Kocak, H., "Dynamics and Bifurcations", Springe r-Verlag, N.Y. 1991
5. Strogatz, S.H., "Nonlinear Dynamics and Chaos", Addison Wesley, Massachusetts, 1995.
6. Helfrack, A.D. and Cooper, W.D., "Modern Electronic Instrumentation & Measurement Techniques", Prentice Hall of India Pvt. Ltd., New Delhi -2001.

ME 607	:	Advance Fluid Dynamics	L	T	P	Credits
			3	0	2	04

- Cartesian Tensors
- Basic Concepts : Types of fluids and basic equations of flow, basic concepts in laminar and turbulent flows.
- Equations Governing Fluid Motion : Navier stokes equations, Boundary layer equations, Exact solutions of N-S equations, Flow between concentric rotating cylinders, Parallel flow of a powder – law fluid.
- Potential Theory : Kelvin's theorem, source, sink, vortex and doublet, development of complex potentials by superposition, Singularities – plane flow past bodies – Dirchlet theorem - Conformal transformation thin aerofoil theory.
- Laminar Boundary Layers : Blasius solution, Boundary Layers with non -zero pressure gradient, separation and vortex shedding.
- Turbulent Flow : Mechanism of turbulence, derivation of governing equations for turbulent flow, K-E model of turbulence, Universal velocity distribution law and friction factor, Kinectic energy of the mean flow and fluctuations, Relaminarization.
- Experimental Techniques : Pressure tubes, Thermal anemometers, Laser – Doppler anemometers, P-I velocimeter.
- Computational Fluid Dynamics : Philosophy of CFD, Governing equations, thin derivation and physical meaning, mathematical behaviour of P.D.E. and its impact on CFD, Finite difference scheme, Grid generation and transformation, Application to FEM and finite volume method for CFD Problems.

Reference:

1. H. Schlichting, "Boundary layer Thoery", McGraw Hill, 1987.
2. Jo. Hinze, "Turbulence", McGraw Hill, 1975.
3. P. Bradshaw, "Turbulence", Springer-Verleg, 1976.
4. Anderson D. A., Tannhill, I.C., and Pletcher, R.H., "Computational Fluid Mechanics and Heat Transfer," Hemisphere Publ. Co., N.Y. 1984.
5. K. Murlishar and T. Sunderajan, "Computational Fluid Flow and Heat Transfer," Narosa Pub. House, New Delhi, 1997.
6. Aderson, John, D., "Computational Fluid Dynamics," McGraw Hill, N.Y., 1995.
7. Fox, R. W. and McDonald, A. T., "Introduction to fluid Mechanics," John, Wiley & Sons, N. Y., 1985.
8. Shapiro, A.H., "The Dynamics and Thermodynamics of Compressible Fluid Flow," The Ronald Press Company, N.Y., 1954.
9. Tennekes, H. and Lumley, J. L., "A First Course in Turbulence," M.I.T., Press, Cambridge, M.A. 1972.
10. Streeter, V.L. and Wylie, E.B., "Fluid Mechanics," McGraw Hill Int. Student Edition, 1979.
11. Zucrow, M. "Gas Dynamics," John Wiley & Sons, 1976.

ME 603	:	Advance Heat Transfer	L	T	P	Credits
			3	0	2	04

- Modes of Heat Transfer.
- 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. Electri cal analogy, graphical & numerical methods. Transient heat conduction with & without temperature gradients within the system, Heat flow in Semi-infinite solids. Application of heisler charts.
- 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 in theory of turbulent heat transfer. Natural convection under different situations. Empirical relations in convection heat transfer.
- Boiling & Condensation.
- Regimes of boiling heat transfer. Heat transfer in condensation. Drop wise & film condensation. Emperical equations.
- Radiation heat transfer properties. Laws of thermal radiation. Shape factors. Radiation heat transfer between black, diffuse & gray surface. Electric network method of solving radiation problems. Radiosity approach. Gas emission & absorption, Bulk Radiations.

Reference:

1. S.P.Sukhatme, "Heat Transfer", University Press (India), 1996
2. J.P.Holamn, " Heat Transfer", McGraw Hill Book. Co., 2002
3. Eckert and Drake, "Heat and Mass Transfer", McGraw Hill, 1960
4. Oziski, M. N. "Heat Transfer – A Basic Approach", McGraw Hill, book comp., N. Y., 1985.
5. Roshenow, W., Hartnett, J., Ganic, P., "Hand Book of Heat Transfer, Vol -1 & Vol-2, McGraw Hill N. Y. 1980.
6. Incropera & Dewitt, "Fundamentals of Heat and Mass Transfer", John Wiley 1996.

ELECTIVE (1)

ME 609	**:**	**Energy & Exergy Analysis of Thermal Systems**	**L**	**T**	**P**	**Credits**
			3	**0**	**2**	**04**

- Basic concepts of energy analysis of thermal systems
- Basic Exergy concepts:
  Classification of forms of exergy, concepts of exergy, exergy concepts for a control region, physical exergy, chemical exergy, exergy concepts for clos ed system analysis, Non-flow exergy.
- Elements of plant Analysis
  Control mass analysis, control region analysis, criteria of performance, pictorial representation of exergy balance, exergy based property diagram
- Exergy analysis of processes
  Expansions process, compression processes, heat transfer process, Mixing & separation process, Chemical process including combustion etc.
- Energy Analysis of Thermal Systems
  Gas turbine plant-Thermal Power Plant-Cogeneration Plant-Captive power plant-Combined cycle Power plant-Refrigeration Plant-Chemical Plant-Lunde air liquification plant, Heat Exchanger etc.

Reference:

1. Kotas J.J. "The Exergy Methods of Thermal Plant Analysis," 2 nd Ed., Krieger Publ. Corp. U.S.A., 1995.
2. Larry, C.W., Schmidt, P.S., and Schmidt, P.S. and David, R.B., "Industrial Energy Management and Utilization", Hemisphere Pub. Corp., Washingto,1989.
3. Seikan, Ishigai, "Steam Power Engineering-Thermal and Hydraulic Design Principles", Cambridge Univ., Press, 1999.
4. Nag, P.K., "Power Plant Engineering-Steam & Nuclear", Tata McGraw Hill Publ., Corp. New Delhi, 1990.
5. Turner, W.C., (Ed.), "Energy Management Handbook", John Wiley & Sons, N.Y., 1982.
6. Dryden, I.G.C., "The Efficient use of Energy", Butterworths, London , 1982
7. Saravanamootoo, H.I.H, & Rogers, G.F.C., "Gas Turbine Theory "Person Education (Singapore) Pvt. Ltd., Indian Branch, New Delhi 2001.
8. Ahrendts J., "The Exergy MethodsEnergy System Analysis" John Wiley & Sons., N.Y., 1980.
9. Gill A.B., "Power Plant Performance", Butter Worths, London, 1984
10. Winternore, D.E. "Advance Thermodynamics for Engineers", Arnold Publ. Corp., 1997.
11. Wark K., "Advance Thermodynamics for Engineers", McGraw Hill, 1995
12. Gunn D. and Horton R., "Industrial Boliers". Longmann Scientific and Technical, UK Gropu Ltd., John Wiley & Sons, N.Y., 1989.
13. Zemanskey M W and Diffman "Heat and Thermodynamics", McGraw Hill, N.Y. 1997.

ME 650	:	Optimization Techniques	L	T	P	Credits
			3	0	2	04

- Single and Multivariable optimization methods, constrained optimization methods, Kuhn-Tucker conditions-Necessary & Sufficiency theorems.
- Linear programming-Traveling salesman problem and Transshipment problems - post optimization analysis.
- Integer programming All integer, Mixed integer and zero -one programming
- Geometric programming – concept – degree of difficulty – solution of unconstrained & constrained non linear problems by geometric programming.
- Dynamic programming.
- Energy System Simulation & optimization/Objectives/constraints, Problems formulation, Unconstrained problems, Constrained Variations, Kuhn-Tucker Conditions.
- Probabilistic Technique – Trade offs between capital & energy using Pinch Analysis.
- Energy-Economy models –Scenario Generation.

Reference:

1. Stocker, W.I. "Design of Thermal System", McGraw Hll, 1987
2. Rao S.S., "Optimization Theory & Applications", Wiley Eastern 1990.
3. New Fville R. "Applied System Analysis", McGraw Hill, Int. Edition 1990
4. K.Deb, "Optimization for Engineering Design", Prentice Hall of India, 1995
5. Reklaitis G.V., Ravindram A., Ragsdell K.M., "Engineering Optimization Met hods & Application", Wiley 1983

ME 611	:	Gas Turbine Cycles and Jet Propulsion	L	T	P	Credits
			3	0	2	04

- Open cycle, Twin Shaft Arrangement, Multi Spool Arrangement of Gas Turbines, Closed Cycles, Air Craft Propulsion, Environmental Issues.
- Ideal Cycles, Combustion and Combustion Chambers, Component Losses, performance calculations Comparison with practical Cycles.
- Criteria for performance, Intake & Propelling Nozzzle efficiency, Simple Turbo -Jet Cycles, Turbo Fan Engine, Turbo -prop engines, Turbo Shaft engines, Thrust augmentation.
- Prediction of Performance of Simple Gas Turbine, Methods for Improving Part -load Performance, Matching Procedure for Turbo -fan Engines Transient behaviour of Gas Turbines, Performance Deterioration and principle of control system.
- Rocket Propulsion, Ramjet Engines.

Reference:

1. Saravanamootoo, H.I.H., & Rogers, G.F.C., "Gas Turbine Theory" Person Education (Singapore) Pvt. Ltd.., Indian Branch, New Delhi 2001.
2. Somasundaram S.L., "Gas Dynamics & Jet Propulsion", New Age Intern ational (P) Ltd., New Delhi, 1996
3. Barlit V., "Lecture Notes Delivered at Bharat Heavy Electricals Ltd.", Vol.I & Vol. II, 1966.
4. Canady G., "Theory of Turbomachines" McGraw Hill Book Co., N.Y. 1964
5. Jain J.K., "Gas Turbine Theory & Jet Propulsion" Khanna Pub lisher, Delhi 1995.
6. Yahya S.M., "Gas Turbine Theory" Ganeshan, V., "Gas Turbine", Tata McGraw Hill, 1999.

ME 602	:	Gas Dynamics & Flow Through Turbomachinery Passages	L	T	P	Credits
			3	0	0	03

- Review of fundamentals - Isentropic, adiabatic, Fanno line and Rayleigh line flows.
- Beltrami flows - Cylindrical stream surfaces - Axisymmetric Beltramic flows - of free - vortex type of forced - vortex type and with constant flow angle - Mass flow rate through annulus - Chocking of flow through annulus.
- Potential flows - Absolute potential flows - flow equations.

- Normal shock - Governing equations - strength of shock waves-schcks in nozzles.
- Oblique shocks - Theoretical analysis - governing equation - Rankine - Hugonoit relations - Prandtl's relation - Strong and weak shocks - oblique shock tables - Mach angles - Mach waves - Prandtl - Meyer expansion - Shock polar diagram - Flow around a corner - Hodograph method for the solution of two- dimensional flows.

- Supersonic flows - Method of characteristics one and two dimensional is entropic flows - two dimensional, irrotational, isentropic, supersonic flow - Design of curved passages - supersonic nozzles - Supersonic cascades.

- Axi-symmetric flows in rotating and stationary PASSAGE - Geometry of blade surfaces - Equilibrium conditions of flow - Influence of conditions at leading edge of blades - Flow conditions at rotor inlet and at rotor outlet - Flow in rotors with arbitrary blades - Methods of solution - correction for finite spacing and thickness of blades - Experimental results.

- Quasi two-dimensional flows in turbomachines - Quasi two dimensional flow on surface of revolution - Irrotational flows on cylindrical stream surfaces - Blade force and circulation - systems of vortex lines as replacement for cascades - Axial cascades replaced by vortex sheet - Biot - Savart's law applied to vortex system for cascade with non -radial blades.

REFERENCES :

1. Aerothermodynamics and flow in turbomachines Vavra, M.H ., John Wiley 1960.
2. They dynamics and thermodynamics of com pressible fluids, Vol. I & II, Shapiro A.H., Ronald Press, 1965.
3. Axial flow compressors - Horlock J.H., Butter worth London,1973.
4. Axial flow turbines - Horlock J.H., Butter worth, London,1973.
5. Mathematical theory of compressible fluid flow - Richard Von Mosses - Academia Press. N.Y., 1958.

ME 606 : HYDRO TURBOMACHINES

L	T	P	Credits
3	0	2	04

- Rotodynamic pumps - pump parameters - similar pumps - non-dimensional parameters - Specific speed - pump classification - different types - ranges of operation.

- Centrifugal pumps - radial and mixed flow - constructional details - Inlet passage - Suction spiral - impeller - recuperator - vaned diffuser - multi-stage pumps - return passage - internal leakage - Wearing ring - axial thrust - balancing devices - Self priming arrangements - bearings and seals - Basic theory - number and shape of blades - blade loading - Head slip - Correction factors - pre-rotation - off-design performance - flow in the volute - flow in the diffuser and return passage - losses - hydraulic losses - volumetric losses - disc friction - mechanical losses - estimation of axial thrust - pump characteristics - stable operation - parallel operation of pumps - pumps in pipe systems - cavitations - NPSH.

- Axial flow pumps - constructional details - pump casing - guide system - impeller - blade adjusting mechanism - diffuser - bearings - blade profiles - aerofoil theory - estimation of blade lift and pump head losses - performance characteristics - cavitation.

- Testing of pumps - test rigs - standard instrumentation - operational characteristics.

- Hydraulic turbines - basic parameters - principles of similarity - model turbines - Unit quantities and specific speed classification range of utilization - Constructional details of water turbines - Reaction turbines - propeller - Kaplan, bulb and Francis
- turbines - Inlet passage - Spiral casing - speed ring guide apparatus - casing-draft tube - pelton wheel - distributor - nozzle - needle regulator - deflector bucket - braking jet.

- Basic theory of reaction turbine - Velocity triangles and their correction - aerofoil theory - flow through different flow passages - volute, guide apparatus, runner and draft tube - hydraulic, volumetric and mechanical losses - energy balance - regulation of discharge - off-design performance - Forces and moments of guide vanes and adjustable blades of runner - axial thrust - cavitation in turbines - Thoma's coefficient - Location of turbine above the tail race.

- Theory of pelton wheel - action of jet on the buckets - flow on bucket surfaces - Hydrodynamic forces and torque on the runner - losses - energy balance.

- Testing of model turbines - test rigs - universal characteristics - separation of losses - cavitation characteristics.

REFERENCES :

1. Centrifugal and axial flow pumps - Stepanoff A.J., John Wiley 1962.
2. Impeller pumps - Lazarkieniz and Torskolanski, Pergamon Press,1965.
3. Hydroelectric engineering practice - Vol.II, Editor Brown JG. 1958.
4. A treatise on applied hydraulics - Addison, H., Chapman and Hall,1954.
5. Hydraulic Turbines - Nechlepa, M., Constable and Co., 1957.

ME 604	:	Thermal Turbomachines	L	T	P	Credits
			3	0	2	04

- Radial flow compressors - Energy transfer - Slip - Pressure coefficient - Isentropic efficiency - Effect of compressibility and pre-whirl - Diffuser - Non-dimensional parameters - surging - choking - performance characteristics.

- Axial flow compressors - Velocity triangles - Blading - number and type of stagings - Air and blade angles - Degree of reaction - Losses - Radial equilibrium and actuator disc theory performance characteristics.

- Steam turbines - Types - Classification - constructional details of different types of steam turbines.

- Gas turbines - Types - Classification - Gas turbines engine and its components - constructional details of components - working principles of different components.

- Power Cycles - Basic steam and gas turbine power cycles - Analysis - Efficiencies - Thermodynamic methods of improving the cycle efficiencies - Heat rate and steam rate calculations.

- Axial flow turbines (Impulse and Reaction) - Velocity triangles -
- Turbine speed - Number of stages and stage work - Gas angles and blade angles.

- Losses in turbines - Reheat factor and condition curve - constant stage efficiency - forms of actual condition curve - Turbine total wheel speed.
- Partial admission turbines - losses - Applications - performance estimation.
- Gas turbine combustion chambers - Requirements - Flame stabilization - combustion efficiency - fuel injection and atomization - Different types of combustors.
- Gas turbine power plant matching characteristics.

REFERENCES :

1. Steam & Gas Turbines - Lee J.F. - McGraw Hill, 1962.
2. Steam turbines - Theory and Design - Shlyakhin. P., Peace Publishers, Moscow, (Translated from Russian by A. Jagamohan), 1965.
3. Theory of gas turbines - Cohen and Rogers Longman, 1974.
4. Fans - Eck B., Pergaman, 1972.
5. Axial flow turbines - Horlack, H.H., Butter worth, London,1973.

ME 608 : Computational Fluid Dynamics

L	T	P	Credits
3	0	4	05

- **Review of Governing Equations 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.

- **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.

- **Solution 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.

- **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.

- Introduction to FVM: Integral Approach, discretization & Higher order scheme

Reference:

1. Anderson D.A., Tannehill J.C., Pletcher R.H., Computational Fluid Mechanics and Heat Transfer, Hemisphere Publishing Corporation, New York, U.S.A. 1984.
2. Murlidhar K. Sunderarajan T., Computational Fluid Flow and Heat Transfer, Narosa Publishing House, New Delhi, 2003
3. Anderson J.D., Jr., Computational Fluid Dynamics McGraw Hill, Inc New York, 1996
4. Ankar S.V., "Numerical Heat Transfer and Flow" Hemisphere Publ.,Corporation, 1985
5. Anderson J.D., Jr., Computational Fluid Dynamics" McGraw Hill, Inc New York, 1995
6. Anderson D.A., Tannehill J.C. Pletcher R.H., "Computational Fluid Mechanics and Heat Transfer" Hemisphere Publ. Corp. N.Y. 1984.
7. Sturt P.A., "Introduction to Numerical Methods", The Macmillan Company, London, 1985
8. Pratap R., "Getting Started with MATLAB", Sounders College Publ. 1995.
9. H.K.Versteag and W.Malalsekara, "An Introduction to Computational Fluid Dynamics", Longman, 1995
10. Carnahan B., "Applied Numerical Methods", John Wiley & Sons 1969.
11. Lewis R.W., "Numerical Methods in Thermal Problem", Vol Vi Part -II, Pine Ridge Press Ltd., 1989.
12. Jain M.k., "Numerical Methods for Scientific and Engineering", 3 rd Edi., New Edge International, 1995.
13. Mathews J.H. "Numerical Methods for Mathematics, Science & Engineering," 2 nd Ed. Prentice Hall of India Pvt. Ltd., New Delhi, 1994.

ME 612 : DESIGN OF THERMAL TURBOMACHINE

L	T	P	Credits
3	0	2	04

- 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.

- 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.

- Design of Turbine flow passages - Introduction - Isentropic Velocity ratio - Energy distribution in turbines - Effect of carryover velocity on energy distribution.

- Impulse turbine flow passages - Blade pitch and width - Blade height - Blade entrance and exit angles - Geometry of impulse blade profiles - Losses in impulse blade passages - Design procedure for single stage and multistage impulse turbines.

- 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.

- 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 - Discussion.

REFERENCES :

1. Lee J.E., "Steam & Gas Turbine", McGraw Hill, 1962.
2. Shlyakhin P., "Steam Turbines-Theory & Design", Peace Publications, Moscow, 1965.
3. Harlock J.H., "Axial Flow Compressors", Butter Worth London, 1958.
4. Harlock J.H., "Axial Flow Turbines", Butter Worth London, 1973.
5. Eck B., "Fans", Pergamon, 1972.
6. Yahya S.M., " Turbo Machine", Tata McGraw Hill, 1992
7. Frank P. Beleier, "Fan Hand Book Selection, Application and Design"
8. Saravanamootoo, H.I.H., & Rogers, G.F.C., "Gas Turbine Theory" Person Education (Singapore) Pvt. Ltd., Indian Branch, New Delhi 2001.

ME 614 : DESIGN OF HYDROTURBOMACHINES

L	T	P	Credits
3	0	2	04

- Design of centrifugal pumps - selection of speed - determination of impeller inlet and outlet dimensions - meridional geometry inlet and exit blade angles - blade geometry - mixed flow pumps - elementary pump - design of twisted blade - design of volute - vaned diffuser and return passage - suction spiral -

- Axial flowpumps - selection of speed - pump casing geometry hub diameter - number of blades and cascade solidity - selection of blade geometry on different flow surfaces - diffuser design.

- Introduction to hydraulic turbine design - Type series and diameter series - selection of type and diameter - Reaction turbine runner spaces - meridional velocity field - elementary turbines - Hydraulic design of Francis turbine - Choice of basic parameters - Inlet and Outlet edges of runner blade - blade profiles on flow surfaces - shape of blade duct-velocity diagrams on different flow surfaces - certain guide lines to finalise the runner design - Guide wheel - Vane geometry and torque on controlling mechanism - Discharge and circulation - spiral - speed ring - draft tube.

- Hydraulic design of axial turbine runners - characteristics of some aerofoils - meridional flow field - blade geometry on each flow surface - procedure to finalize the runner design.

- Hydraulic design of pelton wheel - number of nozzles and their diameter - runner diameter - number of buckets - positioning of buckets - bucket geometry and size -- needle regulator - deflector.

REFERENCES:

1. Andre Kovats, "Design and Performance at Centrifugal & Axial flow pumps & Compressors", Pergamon, 1964.
2. Nechleba M., "Hydraulic Turbine", Constable & Co., 1957.
3. Stapanoff, A.J., "Centrifugal & Axial Flow Pumps", John Wiely, 1962.
4. Lazarkieniz & Troskolanrkis, "Impeller Pumps", Pergamon Press, 1965.
5. Editor Brown, J.G., "Hydroelectric Engineering Practice", Vol-I & II, 1958.
6. Krivechenko G.I., "Hydraulic Mahcines Turbines & Pumps", Moscow - Mir Publications, 1986.
7. Roberson J.A., "Hydraulic Engineering", Jaico Publishing House, Bombay, 1993.
8. Sargo A.S. & Khosla, D.S., "Hydraulic & Hydralics Machines", Salya Publisher, New Delhi, 1989.
9. M.Nechleba, "Hydraulic Turbines".
10. Terry wright "Fluid Machinery Performance Analysis and Design", CRC Press, 1999.

ME 682	:	Design of Heat Exchangers	L	T	P	Credits
			3	0	2	04

Review of Heat Transfer Principles & Co nvection Correlation.

Introduction to Heat Exchangers and classification

Basic Design Methodologies, -NTU Method AND lmtd method

Design of Double Pipe Heat Exchangers

Shell & Tube Type Heat Exchangers, TEMA, Nomenclature, j -Factors

Conventional Design Methods, Bell-Delware Method

Compact Heat Exchangers, j-Factors, Design Method

Condensers Classification and Design Methods for Surface Condensers

Evaporators – classification and Design Methods

Plate Type – Heat Exchangers

Regenerators

Basic Concepts of Mechanical Design of Heat Exchanger

Fixed and Floating Tube Sheet Design, Design of Expansion Bellows

Reference:

1. Ozisik, M.N., "Heat Transfer-A Basic Approach", McGraw Hill Book Company, N.Y., 1985
2. Saunders, E.A.D., "Heat Exchangers – Selection Design and Construction".
3. Longmann Scientific and Technical, N.Y., 1988
4. Kern, D.O., "Process Heat Transfer", McGraw Hill, 1965.
5. Kays, V.A. and London , A.L., "Compact Heat Exchangers" McGraw Hill, 1964
6. Holger Martin, "Heat Exchangers" Hemisphere Publ. Corp. Washington, 1992.
7. Kuppan, T., "Heat Exchanger Design Handbook", Macel Dekker, Inc., N.Y. 2000
8. Shah R.K. , Subbarao, E.C., Mashelkar, R.A., "Heat Transfer Equipment Design", Hemisphere Publ. Corp., 1988
9. Seikan Ishigai, "Steam Power Engineering-Thermal and Hydraulic Design Principles", Cambridge Univ. Press 1999.
10. Gunn, D. and Horton R., "Industrial Boilers; Longman Scientific & Technical UK Group Ltd. & John Wiley & Sons, N.Y. 1989.