MATS UNIVERSITY

Raipur (C.G.)

Syllabus Scheme

(2nd Semester)

For

Master of Technology

In

Turbo-Machinery

MATS School of Engineering & Technology

ARANG, RAIPUR (C.G.)

MATS UNIVERSITY

ARANG, RAIPUR

Subject Code for MATS School of Engg & Tech

2nd Semester-M.Tech (Turbo-Machinery)

S.No.	Subject Code	Subject Name
1	ME 211	GAS DYNAMICS AND FLOW THROUGH TURBO MACHINE PASSAGES
2	ME 212	THERMAL TURBO MACHINES
3	ME 213	HYDRO TURBO MACHINES
4	ME 214	COMPUTATIONAL FLUID DYNAMICS
5	ME 215	ELECTIVE –I
6	ME 216	ADVANCED FLUID MACHINERY LAB
7	ME 217	GAS DYNAMICS LAB
8	ME 218	TURBOMACHINE DESIGN LAB

ELECTIVE –I		
1	ME 2151	DESIGN OF THERMAL TURBOMACHINES
2	ME 2152	DESIGN OF HYDRO TURBO MACHINES
3	ME 2153	ENERGY & EXERGY ANALYSIS

MATS UNIVERSITY

ARANG, RAIPUR

Scheme of Teaching & Examination
M. TECH 2nd SEMESTER TURBO-MACHINERY

S.N.	Subject Code	Subject	Periods per week			Scheme of marks		Total Marks
			L	T	P	ESE	IM	
1.	ME 211	GAS DYNAMICS AND FLOW THROUGH TURBO MACHINE PASSAGES	4	1	-	70	30	100
2.	ME 212	THERMAL TURBO MACHINES	4	1	-	70	30	100
3.	ME 213	HYDRO TURBO MACHINES	4	1	-	70	30	100
4.	ME 214	COMPUTATIONAL FLUID DYNAMICS	4	1	-	70	30	100
5.	ME 215	ELECTIVE –I	4	1	-	70	30	100
6.	ME 216	ADVANCED FLUID MACHINERY LAB	-		3	20	30	50
7.	ME 217	GAS DYNAMICS LAB	-		3	20	30	50
8.	ME 218	TURBOMACHINE DESIGN LAB	-		3	20	30	50
		Total	**20**	**5**	**9**	**410**	**240**	**650**

ELECTIVE –I		
1	ME 2151	DESIGN OF THERMAL TURBOMACHINES
2	ME 2152	DESIGN OF HYDRO TURBO MACHINES
3	ME 2153	ENERGY & EXERGY ANALYSIS

L – Lecture, T – Tutorial, ESE – End Semester Examination,

P – Practical, IM – Internal Marks (Include Class Test & Teacher's Assessments)

MATS UNIVERSITY, RAIPUR

Semester	:	2nd M. Tech Course
Branch	:	Turbo-Machinery
Subject	:	Gas Dynamics and Flow through Turbo Machine Passages
Total Theory Periods	:	45
Total Tutorial Periods	:	15
Code	:	ME 211

UNIT-I INTRODUCTION

Review of fundamentals - Isentropic, adiabatic, Fanno line and Rayleigh line flows. Beltrami flows-Cylindrical stream surfaces-Axisymmetric Beltramic flows -free vortex type-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.

UNIT-II NORMAL AND OBLIQUE SHOCKS

Normal shock-Governing equations-strength of shock waves- shocks 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.

UNIT-III SUPERSONIC FLOWS

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

UNIT-IV AXI-SYMMETRIC FLOWS

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.

UNIT-V FLOW TYPES

Quasi two-dimensional flows in Turbomachines-Quasi two dimensional flows 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.

TEXT BOOK

1. Aerothermodynamics and flow in Turbomachines, Vavra, M.H., John Wiley, 1960.
2. The dynamics and thermodynamics of compressible fluids, Vol. I & II, Shapiro A.H., Ronald Press, 1965.

REFERENCES

1. Axial flow compressors - Horlock J.H., Butter worth London, 1973.
2. Axial flow turbines - Horlock J.H., Butter worth, London, 1973.
3. Mathematical theory of compressible fluid flow - Richard Von Mosses -Academia Press. N.Y., 1958.

MATS UNIVERSITY, RAIPUR

Semester	:	2nd M. Tech Course
Branch	:	Turbo-Machinery
Subject	:	Thermal Turbo Machines
Total Theory Periods	:	45
Total Tutorial Periods	:	15
Code	:	ME 212

UNIT-I RADIAL FLOW COMPRESSORS

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

UNIT II AXIAL FLOW COMPRESSORS

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.

UNIT-III STEAM TURBINES AND GAS TURBINES

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. Axial flow turbines (Impulse and Reaction) - Velocity triangles.

UNIT-IV TURBINE POWER CYCLES AND PERFORMACE

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

UNIT-V COMBUSTION CHAMBERS

Gas turbine combustion chambers - Requirements - Flame stabilization-combustion efficiency - fuel injection and atomization - Different types of combustors. Gas turbine power plant matching characteristics.

TEXT BOOKS:

1. Steam & Gas Turbines - Lee J.F. - McGraw Hill, 1962.
2. Theory of gas turbines - Cohen and Rogers Longman, 1974.

REFERENCES:

1. Steam turbines - Theory and Design - Shlyakhin. P., Peace Publishers, Moscow, (Translated from Russian by A. Jagamohan), 1965.
2. Fans - Eck B., Pergaman, 1972.
3. Axial flow turbines - Horlack, H.H., Butter worth, London, 1973.

MATS UNIVERSITY, RAIPUR

Semester	:	2nd M. Tech Course
Branch	:	Turbo-Machinery
Subject	:	Hydro Turbomachines
Total Theory Periods	:	45
Total Tutorial Periods	:	15
Code	:	ME 213

UNIT-I ROTODYNAMIC PUMPS AND AXIAL FLOW PUMPS

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

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.

UNIT-II CENTRIFUGAL PUMPS

Centrifugal pumps-radial and mixed flow-constructional details–Inlet passage -Suction spiral-impeller-Recuperator-Vaned diffuser-multistage 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.

UNIT-III BASICS OF HYDRAULIC TURBINES

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.

UNIT-IV REACTION TURBINE AND PELTON WHEEL

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.

UNIT-V TESTING OF PUMPS AND TURBINES

Testing of pump-test rig-standard instrumentation-operational characteristics. Testing of model turbines-test rigs-universal characteristics-separation of losses-cavitation characteristics.

TEXT BOOKS:

1. Hydraulic Turbines - Nechlepa, M., Constable and Co., 1957.
2. Centrifugal and axial flow pumps - Stepanoff A.J., John Wiley 1962.

REFERENCES:

1. Impeller pumps - Lazarkieniz and Torskolanski, Pergamon Press, 1965.
2. Hydroelectric engineering practice - Vol. II, Editor Brown JG. 1958.
3. A treatise on applied hydraulics - Addison, H., Chapman and Hall, 1954.

MATS UNIVERSITY, RAIPUR

Semester	:	2nd M. Tech Course
Branch	:	Turbo-Machinery
Subject	:	Computational Fluid Dynamics
Total Theory Periods	:	45
Total Tutorial Periods	:	15
Code	:	ME 214

UNIT-I REVIEW OF GOVERNING EQUATIONS FLUID FLOW & 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.

UNIT-II FINITE DIFFERENCE, DISCRETIZATION, 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.

UNIT-III 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.

UNIT-IV 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.

UNIT-V INTRODUCTION TO FVM

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

TEXT BOOKS:

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. Anderson J.D., Jr., Computational Fluid Dynamics McGraw Hill, Inc New York, 1996.
3. H. K.Versteag and W. Malalsekara, "An Introduction to Computational Fluid Dynamics", Longman, 1995

REFERENCES:

1. Murlidhar K. Sunderarajan T., Computational Fluid Flow and Heat Transfer, Narosa Publishing House, New Delhi, 2003.
2. Ankar S.V., "Numerical Heat Transfer and Flow" Hemisphere Publ., Corporation, 1985.
3. Sturt P.A., "Introduction to Numerical Methods", the Macmillan Company, London, 1985.
4. Pratap R., "Getting Started with MATLAB", Sounders College Publ. 1995.
5. Carnahan B., "Applied Numerical Methods", John Wiley & Sons 1969.

MATS UNIVERSITY, RAIPUR

Semester : 2nd M. Tech Course
Branch : Turbo-Machinery
Subject : Advanced Fluid Machinery Lab
Code : ME 216

LIST OF EXPERIMENTS

1. To study Navier Stokes equation and its applications in engineering.
2. To study the transition from laminar to turbulent flow and to determine the lower critical Reynold's number.
3. To calculate the velocity of the flow through pipe and determine the shear stress distribution.
4. To study about the Conformal Transformation.
5. To study Thin Aerofoil Theory.
6. To study the functioning of Laser Doppler Anemometer.

MATS UNIVERSITY, RAIPUR

Semester : 2nd M. Tech Course
Branch : Turbo-Machinery
Subject : Gas Dynamics Lab
Code : ME 217

LIST OF EXPERIMENTS

1. To study about the isentropic flow through the nozzle.
2. To study about Beltrami flow.
3. To study about the formation of Normal shock waves.
4. To study about the formation of Oblique shock waves.
5. To study about Prandtl's Mayer Expansion process.
6. To study about the Axi-symmetric flows in rotating and stationary passages.

MATS UNIVERSITY, RAIPUR

Semester : 2nd M. Tech Course
Branch : Turbo-Machinery
Subject : Turbomachine Design Lab
Code : ME 217

LIST OF EXPERIMENTS

1. To study about the construction and operation of Centrifugal flow compressors.
2. To study about the construction and operation of Axial flow compressors.
3. To study about the construction and operation of Axial flow Turbine.
4. To study about the construction and operation of Radial flow Turbine.
5. To study the Designing procedure of Gas Turbine Blades.
6. To study about the various problems associated with the operation of Radial flow Turbine.

MATS UNIVERSITY, RAIPUR

Semester	:	2nd M. Tech Course
Branch	:	Turbo-Machinery
Subject	:	Design of Thermal Turbomachines
Total Theory Periods	:	45
Total Tutorial Periods	:	15
Code	:	ME 2151

UNIT-I DESIGN OF CENTRIFUGAL COMPRESSOR

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.

UNIT-II DESIGN OF AXIAL FLOW COMPRESSOR

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.

UNIT-III DESIGN OF TURBINE FLOW PASSAGES

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.

UNIT-IV DESIGN OF REACTION TURBINE FLOW PASSAGES

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.

UNIT-V DESIGN OF REACTION TURBINE FLOW PASSAGES

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.

TEXT BOOKS:

1. Yahya S.M., “Turbo Machine”, Tata McGraw Hill, 1992.
2. Saravanamootoo, H.I.H., & Rogers, G.F.C., “Gas Turbine Theory” Person Education (Singapore) Pvt. Ltd., Indian Branch, New Delhi 2001.

REFERENCES:

1. Shlyakhin P., “Steam Turbines -Theory & Design”, Peace Publications, Moscow, 1965.
2. Harlock J.H., “Axial Flow Compressors”, Butter worth London, 1958.
3. Harlock J.H., “Axial Flow Turbines”, Butter worth London, 1973.

MATS UNIVERSITY, RAIPUR

Semester	:	2nd M. Tech Course
Branch	:	Turbo-Machinery
Subject	:	Design of Hydro Turbo Machines
Total Theory Periods	:	45
Total Tutorial Periods	:	15
Code	:	ME 2152

UNIT-I DESIGN OF CENTRIFUGAL PUMPS

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.

UNIT-II DESIGN OF AXIAL FLOW PUMPS

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

UNIT-III DESIGN OF HYDRAULIC TURBINE

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 finalize the runner design - Guide wheel -Vane geometry and torque on controlling mechanism-Discharge and Circulation - spiral- speed ring- Draft tube.

UNIT-IV DESIGN OF AXIAL TURBINE RUNNERS

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.

UNIT-V DESIGN OF PELTON WHEEL

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.

TEXT BOOKS:

1. Krivechenko G.I., “Hydraulic Machines Turbines & Pumps”, Moscow – Mir Publications, 1986.
2. Nechleba M., “Hydraulic Turbine”, Constable & Co., 1957.
3. Sargo A.S. & Khosla, D.S., “Hydraulic & Hydraulics Machines”, Salya Publisher, New Delhi, 1989.

REFERENCES:

1. Terry Wright “Fluid Machinery Performance Analysis and Design”, CRC Press, 1999.
2. Andre Kovats, “Design and Performance at Centrifugal & Axial flow pumps & Compressors”, Pergamon, 1964.
3. Stepanoff, A.J., “Centrifugal & Axial Flow Pumps”, John Wiley, 1962.

MATS UNIVERSITY, RAIPUR

Semester	:	2nd M. Tech Course
Branch	:	Turbo-Machinery
Subject	:	Energy & Exergy Analysis
Total Theory Periods	:	45
Total Tutorial Periods	:	15
Code	:	ME 2153

UNIT-I BASIC CONCEPTS OF ENERGY
Basic concepts of energy analysis of thermal systems.

UNIT-II BASIC EXERGY CONCEPTS
Classification of forms of exergy, concepts of exergy, exergy concepts for a control region, physical exergy, chemical exergy, exergy concepts for closed system analysis, Non-flow exergy.

UNIT-III ELEMENTS OF PLANT ANALYSIS
Control mass analysis, control region analysis, criteria of performance, pictorial representation of exergy balance, exergy based property diagram.

UNIT-IV EXERGY ANALYSIS OF PROCESSES
Expansions process, compression processes, heat transfer process, Mixing & separation process, Chemical process including combustion etc.

UNIT-V 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.

TEXT BOOKS:

1. Ahrendts J., "The Exergy Methods & Energy System Analysis" John Wiley & Sons., N.Y., 1980.
2. Winternore, D.E. "Advance Thermodynamics for Engineers", Arnold Publ. Corp., 1997.
3. Kotas J.J. "The Exergy Methods of Thermal Plant Analysis," 2nd Ed., Krieger Publ. Corp. U.S.A., 1995.

REFERENCES:

1. Zemanskey M W and Diffman "Heat and Thermodynamics", McGraw Hill, N.Y. 1997.
2. Turner, W.C., (Ed.), "Energy Management Handbook", John Wiley & Sons, N.Y., 1982.
3. Dryden, I.G.C., "The Efficient use of Energy", Butterworths, London, 1982.
4. Saravanamootoo, H.I.H, & Rogers, G.F.C., "Gas Turbine Theory "Person Education (Singapore) Pvt. Ltd., Indian Branch, New Delhi 2001.
5. Seikan, Ishigai, "Steam Power Engineering -Thermal and Hydraulic Design Principles", Cambridge Univ., Press, 1999.