SEMESTER II

MATS UNIVERSITY, RAIPUR

SCHOOL OF ENGINEERING & I.T.

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

Course Objectives
To study classifications of Gas Dynamics and Flow through Turbo Machine Passages
To study construction and working of different Gas Dynamics and Flow through Turbo Machine Passages
To acquire the knowledge and skill of analyzing different Gas Dynamics and Flow through Turbo Machine Passages

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 Turbo machines-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

6. Aerothermodynamics and flow in Turbo machines, Vavra, M.H., John Wiley, 1960.
7. The dynamics and thermodynamics of compressible fluids, Vol. I & II, Shapiro A.H., Ronald Press, 1965.

REFERENCES

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.

Course Outcomes:
Apply knowledge of turbo machinery for understanding, formulating and solving engineering problems.
Acquire knowledge and hands-on competence in the design and development of mechanical systems.
Identify, analysis, and solve mechanical engineering problems useful to the society.
Work effectively with engineering and science teams as well as with multidisciplinary designs

MATS UNIVERSITY, RAIPUR

SCHOOL OF ENGINEERING & I.T.

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

Course Objectives:
To provide a mature approach to the basic principle of classical thermodynamics and to apply it to system surroundings interactions; involving work and heat transfer with associated property changes.
To Use classical thermodynamics principles to develop algebraic relationships among key physical parameters and variable based on analysis of a specified system
Use references that provide tabulated physical data that are useful to mechanical engineers.

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.

Course outcomes:
Apply knowledge of classical thermodynamics for formulating and solving engineering problems.
Acquire knowledge and hands-on competence in applying the concepts of thermal sciences in the design and development of mechanical systems.
Demonstrate creativeness in designing new systems components and processes in the field of engineering in general and mechanical engineering in particular.
Identify, analysis, and solve mechanical engineering problems useful to the society.
Work effectively with engineering and science teams as well as with multidisciplinary designs.
Skillfully use modern engineering tools and techniques for mechanical engineering design, analysis and application.
To continue the study of the applied thermodynamics.

MATS UNIVERSITY, RAIPUR

SCHOOL OF ENGINEERING & I.T.

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

Course Objectives:
To understand boundary layer theory
To formulate basic equations for impact of free jets
To understand construction and working and performance of various Turbines
To understand construction and working & performance of various Pumps
To solve and analyze a variety of fluid mechanics and fluid machinery related problems.

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.

Course Outcomes:
Apply knowledge of fluid mechanics and fluid machinery for understanding, formulating and solving engineering problems.
Acquire knowledge and hands-on competence in applying the concepts of fluid mechanics and fluid machinery in the design and development of mechanical systems.
Identify, analysis, and solve mechanical engineering problems useful to the society.
Work effectively with engineering and science teams as well as with multidisciplinary designs.
Skillfully use modern engineering tools and techniques for mechanical engineering design, analysis and application.

MATS UNIVERSITY, RAIPUR

SCHOOL OF ENGINEERING & I.T.

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

Course Objectives:
Obtaining a solid understanding of the fundamentals of Fluid dynamics
The ability to formulate basic equations for Fluid Engineering problems
.The ability to use tables and figures to determine the friction energy loss for various pipes/ducts geometries and fluid engineering applications
The ability to perform dimensional analysis and identify important parameters

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.

Course Outcomes:
.Apply knowledge of Fluid dynamics formulating and solving engineering problems.
.Acquire knowledge of fluid dynamics for the design and development of mechanical systems.
.Demonstrate creativeness in designing new systems components and processes in the field of engineering in general and mechanical engineering in particular.
Identify, analysis, and solve mechanical engineering problems useful to the society.
.Work effectively with engineering and science teams as well as with multidisciplinary designs.
Skill fully use modern engineering tools and techniques for mechanical engineering design, analysis and application.
.Develop fundamentals to continue the study of the advance subject fluid machinery, Heat and mass transfer etc.

MATS UNIVERSITY, RAIPUR

SCHOOL OF ENGINEERING & I.T.

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

Course Objectives:
To provide a mature approach to the basic principle of classical thermodynamics and to apply it to system surroundings interactions; involving work and heat transfer with associated property changes.
To Use classical thermodynamics principles to develop algebraic relationships among key physical parameters and variable based on analysis of a specified system
Use references that provide tabulated physical data that are useful to mechanical engineers.

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.

Course outcomes:
Apply knowledge of classical thermodynamics for formulating and solving engineering problems.
Acquire knowledge and hands-on competence in applying the concepts of thermal sciences in the design and development of mechanical systems.
Demonstrate creativeness in designing new systems components and processes in the field of engineering in general and mechanical engineering in particular.
Identify, analysis, and solve mechanical engineering problems useful to the society.
Work effectively with engineering and science teams as well as with multidisciplinary designs.
Skillfully use modern engineering tools and techniques for mechanical engineering design, analysis and application.
To continue the study of the applied thermodynamics.

MATS UNIVERSITY, RAIPUR

SCHOOL OF ENGINEERING & I.T.

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

Course Objectives:
To understand boundary layer theory
To formulate basic equations for impact of free jets
To understand construction and working and performance of various Turbines
To understand construction and working & performance of various Pumps
To solve and analyze a variety of fluid mechanics and fluid machinery related problems.

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 flow separation and vortex shedding over an Aerofoil.
7. To study the functioning of Laser Doppler Anemometer.
8. To study the construction and working of Thermal anemometers.
9. To study the functioning of P-I velocimeter.
10. To study grid generation techniques in CFD.

LIST OF EQUIPMENTS

1. Laser Doppler Anemometer.
2. Thermal anemometers.
3. P-I velocimeter.

Course Outcomes:
Apply knowledge of fluid mechanics and fluid machinery for understanding, formulating and solving engineering problems.
Acquire knowledge and hands-on competence in applying the concepts of fluid mechanics and fluid machinery in the design and development of mechanical systems.
Identify, analysis, and solve mechanical engineering problems useful to the society.

Work effectively with engineering and science teams as well as with multidisciplinary designs.
Skillfully use modern engineering tools and techniques for mechanical engineering design, analysis and application.

MATS UNIVERSITY, RAIPUR

SCHOOL OF ENGINEERING & I.T.

Semester : 2nd M. Tech Course

Branch : Turbo-Machinery

Subject : Gas Dynamics Lab

Code : ME 217

Course Objectives
To study classifications of Gas Dynamics and Flow through Turbo Machine Passages
To study construction and working of different Gas Dynamics and Flow through Turbo Machine Passages
To acquire the knowledge and skill of analyzing different Gas Dynamics and Flow through Turbo Machine Passages

LIST OF EXPERIMENTS

1. To study about the isentropic flow through the C-D 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.
7. To study about performance of various types of supersonic nozzles and Supersonic cascades.
8. To study about the Shock polar diagram and Hodograph.

Course Outcomes:
Apply knowledge of turbo machinery for understanding, formulating and solving engineering problems.
Acquire knowledge and hands-on competence in the design and development of mechanical systems.
Identify, analysis, and solve mechanical engineering problems useful to the society.
Work effectively with engineering and science teams as well as with multidisciplinary designs.

MATS UNIVERSITY, RAIPUR

SCHOOL OF ENGINEERING & I.T.

Semester : 2nd M. Tech Course

Branch : Turbo-Machinery

Subject : Turbo machine Design Lab

Code : ME 217

Course Objectives
To study classifications of gas turbine cycle
To study construction and working of different jet propulsion
To acquire the knowledge and skill of analyzing Gas Turbine Cycles and Jet Propulsion

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.

Course Objectives
To study classifications of Gas Dynamics and Flow through Turbo Machine Passages
To study construction and working of different Gas Dynamics and Flow through Turbo Machine Passages
To acquire the knowledge and skill of analyzing different Gas Dynamics and Flow through Turbo Machine Passages