MATS UNIVERSITY

Raipur (C.G.)

Syllabus Scheme

(1st Semester)

For

Master of Technology

In

Turbo-Machinery

MATS School of Engineering & Technology

ARANG, RAIPUR (C.G.)

MATS UNIVERSITY
ARANG, RAIPUR

Scheme of Teaching & Examination
M. TECH 1st SEMESTER TURBO-MACHINERY

S.N.	Code	Subject	Periods per week			Scheme of Marks		Total Credit
			L	T	P	ESE	IM	
1.	MT100	Research Methodology & IPR	3	-	-	70	30	3
2.	MT110	Finite Element Methods	3	-	-	70	30	4
3.	MT111	Experimental Techniques	3	-	-	70	30	4
4.	MT112	Advanced Fluid Dynamics	3	-	-	70	30	3
5.	MT113	Gas Turbine Cycle & Jet Propulsion	3	-	-	70	30	3
6.	MT114	Gas Turbine & Jet Propulsion Lab	-	-	2	30	20	2
7.	MT115	Fluid Dynamics Lab	-	-	2	30	20	2
		Total	**15**	**0**	**4**	**410**	**190**	**21**

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

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

MATS UNIVERSITY, RAIPUR

Semester	:	1st M. Tech Course
Branch	:	Turbo-Machinery
Subject	:	Research Methodology & IPR
Total Theory Periods	:	48
Total Tutorial Periods	:	00
Code	:	MT100

Unit I: Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Unit II: Effective literature studies approaches, analysis Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Unit III: Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Unit IV: Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Unit V: New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

REFERENCES:

1. 1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
3. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd, 2007. • Mayall, "Industrial Design", McGraw Hill, 1992.
5. Niebel, "Product Design", McGraw Hill, 1974. • Asimov, "Introduction to Design", Prentice Hall, 1962.
6. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age", 2016.
7. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

MATS UNIVERSITY, RAIPUR

Semester	:	1st M. Tech Course
Branch	:	Turbo-Machinery
Subject	:	Finite Element Methods
Total Theory Periods	:	48
Total Tutorial Periods	:	00
Code	:	MT110

UNIT-I INTRODUCTION

Review of various approximate methods – Raleigh Ritz's, Galerkin and finitedifference methods-Governing equation and convergence criteria of finite element method.

UNIT-II DISCRETE ELEMENTS

Bar elements, uniform sections, mechanical and thermal loading, varying section, truss analysis. Beam element - problems for various loadings and boundary conditions - longitudinal and lateral vibration. Use of local and natural coordinates.

UNIT-III CONTINUUM ELEMENTS

Plane stress, Plane strain and axisymmetric problems, constant and linearstrain,triangular elements, stiffness matrix, axisymmetric load vector.

UNIT-IV ISOPARAMETRIC ELEMENTS

Definitions, Shape function for 4, 8 and 9 nodal quadrilateral elements, Stiffnessmatrix and consistent load vector, Gaussian integration

UNIT-V FIELD PROBLEM

Heat transfer problems, Steady state fin problems, Derivation of element matrices fortwo dimensional problems, Torsion problems.

TEXT BOOK

1. Tirupathi.R. Chandrapatha and Ashok D. Belegundu – Introduction to FiniteElements in Engineering – Printice Hall India, Third Edition, 2003.
2. Rao. S.S., Finite Element Methods in Engineering, Butterworth and Heinemann,2001.

REFERENCES

8. Reddy J.N.–An Introduction to Finite Element Method – McGraw Hill – 2000.
9. Krishnamurthy, C.S., Finite Element Analysis, Tata McGraw Hill, 2000.
10. Bathe, K.J. and Wilson, E.L., Numerical Methods in Finite ElementsAnalysis,Prentice Hall of India, 1985.
11. Robert D Cook, David S Malkus, Michael E Plesha, 'Concepts and Applicationsof Finite Element Analysis', 4th edition, John Wiley and Sons, Inc., 2003.
12. Larry J Segerlind, 'Applied Finite Element Analysis', Second Edition, John Wileyand Sons, Inc. 1984.

MATS UNIVERSITY, RAIPUR

Semester	:	1st M. Tech Course
Branch	:	Turbo-Machinery
Subject	:	Experimental Techniques
Total Theory Periods	:	48
Total Tutorial Periods	:	00
Code	:	MT111

UNIT-I

Basic concepts of Measurement, Statistical Analysis of Experimental Data Method of LeastSquares, Uncertainty Analysis.

UNIT-II

Response characteristics of Instruments – 1st & 2nd order instrument. Transducers, Vibration & Noise measurements

UNIT-III

Theory of strain gauges, Advance & Specific measurements –Stress & Strain Measurement by Photo Elastic Bench, Hotwire & Laser Doppler Anemometry.

UNIT-IV

Thermal & Transport property measurement, Thermo gravimetry, Gas Chromatography, Air Pollution & Nuclear radiation measurement.

UNIT-V

NDT, Radiography, Ultrasonography, Wind Tunnel Testing, Data Acquisition System.

REFERENCES:

1. Holman, J.P, "Experimental Methods for Engineers" 5th Ed. McGraw hillInternational Edition, 1989.
2. Doeblin, E.O., "Measurement System – Application and Design – McGraw HillInternational Ed., 1990.
3. Eckman, D.P. "Industrial Instrumentation", Wiley Eastern Ltd., New Delhi, 1990.
4. Hale, J. and Kocak, H., "Dynamics and Bifurcations", Springer-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.

MATS UNIVERSITY, RAIPUR

Semester	:	1st M. Tech Course
Branch	:	Turbo-Machinery
Subject	:	Advance Fluid Dynamics
Total Theory Periods	:	48
Total Tutorial Periods	:	00
Code	:	MT112

UNIT-I

Cartesian Tensors, Basic Concepts: Types of fluids and basic equations of flow, basic concepts inlaminar 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.

UNIT-II

Potential Theory: Kelvin's theorem, source, sink, vortex and doublet, development ofcomplex potentials by super position, Singularities – plane flow past bodies – Dirchlettheorem - Conformal transformation and thin aerofoil theory.

UNIT-III

Laminar Boundary Layers: Blasius solution, Boundary Layers with non -zero pressuregradient, separation and vortex shedding.Turbulent Flow: Mechanism of turbulence, derivation of governing equations forturbulent flow, K-Ɛ model of turbulence, Universal velocity distribution law andfriction factor, Kinetic energy of the mean flow and fluctuations, Relaminarization.

UNIT-IV

Experimental Techniques: Pressure tubes, Thermal anemometers, Laser – Doppleranemometers, P-I velocimeter.

UNIT-V

Computational Fluid Dynamics: Philosophy of CFD, Governing equations, thinderivation and physical meaning, mathematical behaviour of P.D.E. and its impact onCFD, Finite difference scheme, Grid generation and transformation, Application toFEM and finite volume method for CFD Problems.

REFERENCES:

1. H. Schlichting, "Boundary layer Theory", 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 Mechanicsand 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. Anderson, 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. StudentEdition, 1979.
11. Zucrow, M. "Gas Dynamics," John Wiley & Sons, 1976.

MATS UNIVERSITY, RAIPUR

Semester	:	1st M. Tech Course
Branch	:	Turbo-Machinery
Subject	:	Gas Turbine Cycles and Jet Propulsion
Total Theory Periods	:	48
Total Tutorial Periods	:	00
Code	:	MT113

UNIT-I

Open cycle, Twin Shaft Arrangement, Multi Spool Arrangement of Gas Turbines,Closed Cycles, Aircraft Propulsion, and Environmental Issues.

UNIT-II

Ideal Cycles, Combustion and Combustion Chambers, Component Losses,performancecalculations Comparison with practical Cycles.

UNIT-III

Criteria for performance, Intake & Propelling Nozzle efficiency, Simple Turbo –JetCycles, Turbo Fan Engine, Turbo -prop engines, Turbo Shaft engines, Thrustaugmentation.

UNIT-IV

Prediction of Performance of Simple Gas Turbine, Methods for Improving Part–loadPerformance, Matching Procedure for Turbo -fan Engines, Transient behaviour of GasTurbines, Performance Deterioration and principle of control system.

UNIT-V

Rocket Propulsion-Classification, Operation, Performance, Ramjet Engines.

REFERENCES:

1. Saravanamootoo, H.I.H., & Rogers, G.F.C., "Gas Turbine Theory" PersonEducation(Singapore) Pvt. Ltd.., Indian Branch, New Delhi 2001.
2. Somasundaram S.L., "Gas Dynamics & Jet Propulsion", New Age International (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 Publisher, Delhi 1995.
6. Yahya S.M., "Gas Turbine Theory", New Age International Publishers, New Delhi 1982.
7. Ganeshan, V., "Gas Turbine", Tata McGrawHill, 1999.

MATS UNIVERSITY, RAIPUR

Semester : 1st M. Tech Course
Branch : Turbo-Machinery
Subject : Gas Turbine and Jet Propulsion Laboratory
Code : MT114

LIST OF EXPERIMENTS

1. To study about the operation of Open cycle and Closed Cycle Gas Turbine Engines.
2. To estimate the performance of Gas Turbine Engine.
3. To study about the construction and operation of Turbojet Engine.
4. To study about the construction and operation of Turbofan Engine.
5. To study about the construction and operation of Ramjet Engine.
7. To estimate the performance of Combustion Chamber of Gas Turbine Engine.
8. To estimate the performance of De-Laval Nozzle.
9. To study about the construction and operation of Rocket Engines.
10. To study about the matching procedure of Turbofan Engines.
11. Part-load Performance estimation of Gas Turbine.

LIST OF EQUIPMENTS

1. Gas Turbine Performance Test Setup
2. Combustion Chamber Test Setup
3. De-Laval Nozzle Test Setup.
4. Gas Turbine Part-load Performance Test Setup

MATS UNIVERSITY, RAIPUR

Semester : 1st M. Tech Course
Branch : Turbo-Machinery
Subject : Fluid Dynamics Laboratory
Code : MT115

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.

MATS UNIVERSITY

Raipur (C.G.)

CBCS

Syllabus Scheme

(2nd Semester)

For

Master of Technology

In

Turbo-Machinery

MATS School of Engineering & Technology

ARANG, RAIPUR (C.G.)

MATS UNIVERSITY

ARANG, RAIPUR

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

S.N.	Code	Subject	Periods per week			Scheme of marks		Total Credit
			L	T	P	ESE	IM	
1.	MT210	Advanced Gas Dynamics	3	-	-	70	30	3
2.	MT211	Thermal Turbo Machines	3	-	-	70	30	4
3.	MT212	Hydro Turbo Machines	3	-	-	70	30	3
4.	MT213	Computational Fluid Dynamics	3	-	-	70	30	4
5.	MTPXXX	Professional Elective-I	3	-	-	70	30	3
6.	MT214	Gas Dynamics Lab	-	-	2	30	20	2
7.	MT215	CFD Lab	-	-	2	30	20	2
Total			**15**	**-**	**4**	**410**	**190**	**21**

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	:	Advanced Gas Dynamics
Total Theory Periods	:	45
Total Tutorial Periods	:	15
Code	:	MT210

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

1. Aerothermodynamics and flow in Turbo machines, 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	:	MT211

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 Turbo machines
Total Theory Periods	:	45
Total Tutorial Periods	:	15
Code	:	MT212

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	:	MT213

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 : Gas Dynamics Lab
Code : MT214

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.

MATS UNIVERSITY, RAIPUR

Semester : 2nd M. Tech Course
Branch : Turbo-Machinery
Subject : CFD Lab
Code : MT215

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.

MATS UNIVERSITY

Raipur (C.G.)

Syllabus Scheme

(3rd Semester)

For

Master of Technology

In

Turbo-Machinery

MATS School of Engineering & I.T.

ARANG, RAIPUR (C.G.)

MATS UNIVERSITY

ARANG, RAIPUR

Scheme of Teaching & Examination
M. TECH 3rd SEMESTER TURBO-MACHINERY

III - Semester

S.N.	code	Subject	Periods per week			Scheme of marks		Total Credit
			L	T	P	ESE	IM	
1.	MTPXXX	Professional Elective-II	3	-	-	70	30	4
2.	MTPXXX	Professional Elective-III	3	-	-	70	30	3
3.	MT310	Turbo Machine Design Lab	-	-	2	30	20	2
4.	MT311	PROJECT WORK PHASE – I	-	-	18	140	60	12
Total			**6**	**0**	**20**	**310**	**140**	**21**

P – Practical, IM – Internal Marks (Include Class Test & Teacher's Assessments)
L – Lecture, T – Tutorial, ESE – End Semester Examination,

MATS UNIVERSITY, RAIPUR

Semester : 3rd M. Tech Course
Branch : Turbo-Machinery
Subject : Turbo Machine Design Lab
Code : MT310

LIST OF EXPERIMENTS

1. To carry out flow simulation for the supersonic flow over a flat plate.
2. To carry out flow simulation for turbulent flow in a pipe.
3. Flow Simulation over a circular cylinder with circulation effect.
4. Generation velocity profile for laminar flow
5. Generation of velocity profile for turbulent flow
6. Nussent number determination for a flow with constant it edition
7. Nussent number determination for a flow with heat edition at constant temperature
8. Simulation of flow over a car body.
9. Simulation of supersonic flow over an aircraft.
10. Determination of drag for a flow over a body
11. Analysis of 2-D transient heat flow over a plate
12. To study about different K-E models.
13. Friction factor for laminar flow
14. Friction factor for turbulent flow
15. Shear stress distribution for a flow in horizontal duct
16. To study about Navier-Stoke's Equation and various methods for its solution.
17. To study about various Grid-less techniques used in CFD.
18. To study about Moving Mesh and Auto-Mesh techniques.
19. To study about species transport and energy transport equation for combustion analysis.

LIST OF EQUIPMENTS

1. Computers with minimum 1 GB RAM, Pentium-IV Processor,
2. Ansys Fluent and Gambit packages,
3. ANSYS- 12 with Fluent and CFX,
4. UPS 10 KVa 3-Phase.

MATS UNIVERSITY, RAIPUR

Semester	:	3rd M. Tech Course
Branch	:	Turbo-Machinery
Subject	:	Project Work Phase – I
Code	:	MT311

The objective of the phase – I of the student's project work is to prepare themselves to undertake lively project which will found end application to the industry /society. Preparation for the project work involve

- ✓ The project for M. Tech should be carried by individual student.
- ✓ Make a preliminary survey and data collection or literature review of the project proposed in the next semester.
- ✓ Conduct a thorough literature survey and publish or present a paper of the proposed work in any one of the forthcoming International seminars/ conferences/journals.
- ✓ Plan for necessary supports, facilities, analytical tools and fixation of faculties /supervisors for the final semester project work.
- ✓ Partial work of the project is to be carried out in Phase-I and remaining in Phase-II which leads to the Thesis submission at the end of the project work.
- ✓ Project should be research oriented and at least two papers should be presented/accepted in the International Journals for the Thesis submission.

MATS UNIVERSITY

Raipur (C.G.)

Syllabus Scheme

(4th 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

4th Semester- M. Tech (Turbo-Machinery)

S. No.	Subject Code	Subject Name
1	MT410	Project Work Phase – II

MATS UNIVERSITY

ARANG, RAIPUR

Scheme of Teaching & Examination
M. TECH 4th SEMESTER TURBO-MACHINERY

S.N.	Subject Code	Subject	Periods per week			Scheme of marks		Total Marks
			L	T	P	ESE	IM	
7.	MT410	Project Work Phase – II	-	-	36	315	135	450
		Total	**-**	**-**	**36**	**315**	**135**	**450**

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

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

MATS UNIVERSITY, RAIPUR

Semester	:	4th M. Tech Course
Branch	:	Turbo-Machinery
Subject	:	Project Work Phase – II
Code	:	MT410

The objective of the project work is to enable the students to work individually on a project involving theoretical and experimental studies related to the branch of study. Every project work shall have a guide who is the member of the faculty of the institution. Students can opt for the co-guide from industries/ other colleges to get the necessary supervision. Six periods per week shall be allotted in the time table and this time shall be utilized by the students to receive the directions from the guide, on library reading, laboratory work, computer analysis or field work as assigned by the guide and also to present in periodical seminars on the progress made in the project.

Each student shall finally produce a comprehensive report in the form of Thesis covering background information, literature survey, problem statement, project work details and conclusion. This final report shall be typewritten form as specified in the guidelines. It is mandatory that the project selected should be research oriented and at least two papers/articles related to the project work should be published/ accepted for publication in the international journals for Thesis submission.

The continuous assessment shall be made as prescribed by the regulation.

List of Professonal Electives (M.Turbo Machinery)		
S.No.	**Code**	**Subject Name**
1	MTP100	Energy & Exergy Analysis
2	MTP101	High Temperature Materials
3	MTP102	Power Plant Control and Instrumentation
4	MTP103	Power Plant Steam Generators
5	MTP104	Design of Experiments
6	MTP105	Design of Thermal Turbo Machines
7	MTP106	Design of Hydro Turbo Machines
8	MTP107	Design of Pumps and Compressors
9	MTP108	Fatigue and Fracture Mechanics
10	MTP109	Optimization Techniques
11	MTP110	Heat Transfer and Heat Exchangers in Power Plants
12	MTP111	Fluid Power System
13	MTP112	Fuels and Combustion
14	MTP113	Design of Heat Exchanger
15	MTP114	Design of Heat Transfer Equipments
16	MTP115	Advanced Heat Transfer

MATS UNIVERSITY, RAIPUR

Subject	:	Energy & Exergy Analysis
Total Theory Periods	:	45
Total Tutorial Periods	:	15
Code	:	MTP100

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.

MATS UNIVERSITY, RAIPUR

Subject	:	High Temperature Materials
Total Theory Periods	:	45
Total Tutorial Periods	:	15
Code	:	MTP101

UNIT-I CREEP

Factors influencing functional life of components at elevated temperatures, definition of creep curve, various stages of creep, metallurgical factors influencing various stages, effect of stress, temperature and strain rate.

UNIT-II DESIGN FOR CREEP RESISTANCE

Design of transient creep time, hardening, strain hardening, expressions of rupture life of creep, ductile & brittle materials, Monkman- Grant relationship.

UNIT-III FRACTURE

Various types of fracture, brittle to ductile from low temperature to high temperature, cleavage fracture, ductile fracture due to micro void coalescence-diffusion controlled void growth; fracture maps for different alloys and oxides.

UNIT-IV OXIDATION AND HOT CORROSION

Oxidation, Pilling, Bedworth ratio, kinetic laws of oxidation- defect structure and control of oxidation by alloy additions, hot gas corrosion deposit, modified hot gas corrosion, fluxing mechanisms, effect of alloying elements on hot corrosion, interaction of hot corrosion and creep, methods of combat hot corrosion.

UNIT-V SUPER ALLOYS AND OTHER MATERIALS

Iron base, Nickel base and Cobalt base super alloys, composition control, solid solution strengthening, precipitation hardening by gamma prime, grain boundary strengthening, TCP phase, embrittlement, solidification of single crystals, Intermetallics, high temperature ceramics.

TEXT BOOKS

1. Raj. R., “Flow and Fracture at Elevated Temperatures”, American Society for Metals, USA, 1985.
2. Hertzberg R. W., “Deformation and Fracture Mechanics of Engineering materials”, 4th Edition, John Wiley, USA, 1996.
3. Courtney T.H, “Mechanical Behavior of Materials”, McGraw-Hill, USA, 1990.

REFERENCES

1. Boyle J.T, Spencer J, “Stress Analysis for Creep”, Butterworths, UK, 1983.
2. Bressers. J., “Creep and Fatigue in High Temperature Alloys”, Applied Science, 1981.
1. McLean D., “Directionally Solidified Materials for High Temperature Service”, The Metals Society, USA, 1985.

MATS UNIVERSITY, RAIPUR

Subject	:	Power Plant Control & Instrumentation
Total Theory Periods	:	45
Total Tutorial Periods	:	15
Code	:	MTP102

UNIT-I: INTRODUCTION AND BASIC CONCEPTS

Basics of Chemical engineering unit operations like; Fluid flow processes, including fluids transportation, filtration, and solids fluidization., Heat transfer processes, including evaporation, condensation, and heat exchange, Mass transfer processes, including gas absorption, distillation, extraction, adsorption, and drying, Thermodynamic processes, including gas liquefaction, and refrigeration, Mechanical processes, including solids transportation, crushing and pulverization, and screening and sieving. Basic concepts behind pumps, compressors, fans, blowers etc.

UNIT-II: HEAT AND MASS TRANSFER

A. Heat Transfer: Importance of heat transfer in Chemical Engineering operations, Principles of heat flow in fluids, Heat transfer to fluids without phase change, Heat Transfer to fluids with phase change, Heat Exchange equipment, Evaporation Principle & types of evaporation, Crystallization: Definition, Nucleation and Crystal Growth. B. Mass Transfer: Distillation: Vapor- Liquid Equilibrium, Ideal Solutions, Relative volatility, Azeotropic mixtures, Methods Of distillation: Flash, Continuous, Multi-component system, Material balance and Analysis of Fractionating column by McCabe Thiele method. Drying: Theory and Mechanism of Drying, Steady and Unsteady Drying, moisture content, total time of drying, Characteristics, Classification and selection of Industrial dryers.

UNIT-III RENEWABLE POWER PLANT CONTROL AND INSTRUMENTATION

A. Energy sources, their availability, worldwide energy production, energy scenario of India. Introduction to Power generation: Classification: Renewable and non-renewable energy generation resources. Renewable: Small Hydro, modern biomass, wind power, solar, geothermal and bio-fuels. Nonrenewable: fossil fuels (coal, oil and natural gas) and nuclear power. Hydroelectric Power Plant: Site selection, Hydrology, classification of Hydropower plants, Types of Turbines for hydroelectric power plant, pumped storage plants, storage reservoir plants. Wind Energy: Power in wind, Conversion of wind power, types of wind turbine, and modes of operation, wind mill, wind pumps, wind farms, safety. Solar Energy: Solar resource, solar energy conversion systems: Solar PV technology: Block diagram of PV system, advantages and limitations. Solar thermal energy system: Principle, solar collector and its types, solar concentrator and its types, safety. Nuclear Power Plant: Nuclear power generation, control station and reactor control.

UNIT-IV THERMAL POWER PLANT CONTROL AND INSTRUMENTATION

A. Thermal Power Plant- Method of power generation, layout and energy conversion process, material handling systems. B. Boiler: Types of boilers like FBC, CFBC, DIPC, Fluidized Bed, boiler safety standards, Combustion control, air to fuel ratio control, three element drum level control, steam temperature and pressure control, burner management systems, boiler interlocks. Instrumentation for Boiler ancillaries viz. water treatment, electro-static precipitator, soot blower, economizer, de aerator, super heater, chemical dosing systems, air pre-heater, coal and ash handling systems, fuel storage and distribution, Bag House Filters.

UNIT-V CONTROL AND INSTRUMENTATION AND ERGONICS

Excess Air –Combustion Chemistry and products of Combustion- Requirements of Excess Combustion air –Calculation of efficiency of boilers –Input /output method – Heat loss method. Types of Turbines, Turbine instrumentation and control, start-up and shut-down, thermal stress control, condition monitoring & power distribution instrumentation. Synchronous, Induction generators Speed, Vibration, shell temperature monitoring and control-steam pressure control – lubricant oil temperature control – cooling system, Comparison of thermal power plant, hydroelectric power plant, wind, solar, nuclear power plant on the basis of: Performance, efficiency, site selection, Economics-capital and running, safety standards, pollution, effluent management and handling. Power plant safety, Pollution monitoring, control Sound, Air, smoke, dust, study of Electrostatic precipitator

TEXT BOOKS:

1. McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering", McGraw- Hill VII Edn., 2004.
2. Boiler Control Systems, David Lindsley, Mc-Graw Hill
3. Power Plant Engineering, P.K.Nag, 3rd edition, 2010. McGraw Hill.
4. Power Plant Instrumentation, K. Krishnaswamy, M. PonniBala, PHI Learning Pvt. Ltd., 2011.

REFERENCE BOOKS:

1. Process Control, B.G. Liptak
2. Power Plant Engineering, Domkundwar
3. Non-conventional energy resources.by B. H. Khan, McGraw Hill, New Delhi.
4. Renewable energy Technology.Chetan Singh Solanki, Prentice Hall Publication.
5. Solar Energy, by S. P. Sukhatme, Tata McGraw Hill, New Delhi.
6. Nonconventional Energy Sources. G. D. Rai, Khanna Publication.
7. Energy Management Handbook: W.C. Taeruer
8. Pollution: M.N.Rao and H.V. Rao.

MATS UNIVERSITY, RAIPUR

Subject	:	Power Plant Steam Generators
Total Theory Periods	:	45
Total Tutorial Periods	:	15
Code	:	MTP103

UNIT-I Analysis of Steam cycles: Rankine cycle, Carnot cycle, effect of variation of steam condition on plant thermal efficiency, reheating of steam, regeneration, regenerative feed water heating, Carnotization of Rankine cycle, optimum degree of regeneration, Supercritical pressure cycle, Deaerator, typical layout and efficiencies of a steam power plant, Cogeneration of Power and Process Heat, Numerical Problems. Combined cycle power generation: Flaws of steam as working fluid in Power Cycle, Characteristics of ideal working fluid, Binary vapor cycles, combined cycle plants, gas turbine-steam turbine power plant, MHD-steam power plant, Thermionic-Steam power plant.

UNIT-II Fuels and combustion :Coal, oil, natural and petroleum gas, emulsion firing, coal – oil and coal – water mixtures, synthetic fuels, biomass, combustion reactions, heat and enthalpy of combustion, theoretical flame temperature, free energy of formation, equilibrium constant, effect of dissociation, Numerical problems. Combustion Mechanisms: Kinetics of combustion, mechanisms of solid fuel combustion, kinetic and diffusion control, mechanisms of pulverized coal combustion and fuel-bed combustion, fluidized bed combustion, coal gasifiers, combustion of fuel oil or gas or combined gas fuel oil burners.

UNIT-III Steam Generators: Basic type of steam generators, fire tube/water tube boilers, economizers, superheaters, reheaters, steam generator control, air preheater, fluidized bed boilers, electrostatic precipitator, fabric filters and bag houses, ash handling system, feed water treatment, deaeration, evaporation, internal treatment, boiler blow down, steam purity. Condenser, feed water and circulating water systems: Need of condenser, direct contact condensers, feed water heaters, circulating water system, cooling towers, calculations, Numerical Problems.

UNIT-IV Nuclear Power Plants: Chemical and Nuclear reactions, nuclear stability and binding energy, radioactive decay and half life, nuclear fission, chain reaction, neutron energies. Neutron flux and reaction rates, moderating power and moderating ratio, variation of neutron cross sections with neutron energy, neutron life cycle. Reflectors, Types of Reactor, PWR, BWR, gas cooled reactors. Liquid metal fast breeder reactor, heavy water reactors, Fusion Power reactors, Numerical problems.

UNIT-V Hydro Electric Power Plant: Introduction, advantages and disadvantages of water power, optimization of hydro – thermal mix, hydrological cycles, storage and pondage, essential elements of hydro electric power plant, classification, hydraulic turbines – Pelton wheel, Francis turbine, Propeller and Kaplan turbines, Deriaz turbine, Bulb Turbine, Comparisons of Turbines, Selection of Turbines, Numerical Problems.

TEXT BOOKS:

1. Power Plant Engineering - P.K. Nag, Tata McGraw-Hill Publications.
2. Power Plant Engineering - M.M. EI-Wakil, McGraw- Hill Publications.

REFERENCE BOOKS:

1. Power plant Engineering RK Rajput S.Chand Publications

MATS UNIVERSITY, RAIPUR

Subject	:	Design of Experiment
Total Theory Periods	:	45
Total Tutorial Periods	:	15
Code	:	MTP104

UNIT-I Introduction to experimental design principles, simple comparative experiments, introduction to R language and its applications in DOE problems. Single factor experiments, randomized blocks, Latin square designs and extensions, introduction to R language. Simple Comparative Experiments, Single Factor Analysis of Variance (ANOVA), Randomized Complete Block Designs (RCBD), Latin Square Designs, Graeco-Latin Square Designs, Factorial Designs.

UNIT-II Introduction to factorial designs, two levels, 2k factorial designs, confounding and blocking in factorial designs, applications to manufacturing problems. Fractional factorial designs, two-level, three-level and mixed-level factorials and fractional factorials, applications to quality control problems. Fractional Factorial Designs, Applications of Factorial Designs to manufacturing problems, Regression Models, Residual Analysis, Response Surface Methods, Random Factors Experiments.

UNIT-III Regression models including multiple regression models and its application to transportation scheduling problems. Response surface methodology, parameter optimization, robust parameter design and its application to control of processes with high variability.

UNIT-IV Random and mixed effects models, nested and split plot and strip plot designs and its application to semiconductor manufacturing problem. Repeated measures design, analysis of covariance and its applications in comparing alternatives.

UNIT-V Design of computer experiments and the applications in industrial engineering problems. Nested Designs, Split Plot Designs, Robust Design, Application to Industry problems, Process Optimization. Using R software, Procedures, Syntax, Data Description, Variables, Formats, etc of R Language, Development & Analysis of Questionnaire in R, Psychometrics Using R, Programming DOE Techniques in R, etc.

TEXT BOOKS:

1. The Design of Experiments – R. A. Fischer, Oliver & Boyd, 1935.
2. Design of Experiments for Engineers and Scientists - Jiju Antony, 1st Edition, Elsevier.
3. George E. P. Box, J. Stuart Hunter, William G. Hunter, Statistics for Experimenters: Design, Innovation, and Discovery, 2nd Edition.

REFERENCE BOOKS:

1. Douglas C. Montgomery, Design and Analysis of Experiments.
2. Max Morris, Design of Experiments: An Introduction Based on Linear Models (Chapman & Hall/CRC Texts in Statistical Science).
3. Angela M. Dean (Author), Daniel Voss, Design and Analysis of Experiments (Springer Texts in Statistics).
4. C. F. Jeff Wu, Michael S. Hamada, Experiments: Planning, Analysis, and Optimization (Wiley Series in Probability and Statistics).
5. Robert L. Mason, Richard F. Gunst, James L. Hess, Statistical Design and Analysis of Experiments, with Applications to Engineering and Science

6. Peter W. M. John, Statistical Design and Analysis of Experiments (Classics in Applied Mathematics No 22.).

MATS UNIVERSITY, RAIPUR

Subject	:	Design of Thermal Turbo Machines
Total Theory Periods	:	45
Total Tutorial Periods	:	15
Code	:	MTP105

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:

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

MATS UNIVERSITY, RAIPUR

Subject	:	Design of Hydro Turbo Machines
Total Theory Periods	:	45
Total Tutorial Periods	:	15
Code	:	MTP106

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

Subject	:	Design of Pumps and Compressors
Total Theory Periods	:	45
Total Tutorial Periods	:	15
Code	:	MTP107

UNIT-I: FUNDAMENTALS OF FLUID MACHINERY
Introduction to pumps, Introduction to blowers and compressors, Basic equations of energy transfer between fluid and rotor, Performance characteristics, Dimensionless parameters, Specific speed, stage velocity triangles, work and efficiency.

UNIT-II: RECIPROCATING PUMPS
Introduction: Types, Component and Working of Reciprocating pump, Discharge, Work done and power required to drive for single acting and double acting, Coefficient of discharge, slip, Effect of acceleration of piston on velocity and pressure, indicator diagram, Air Vessel, Operating characteristics.

UNIT-III: DESIGN OF PUMPS
Design procedure and design optimization of Pumps, selection of pumps, Thermal design- Selection of materials for high temperature and corrosive fluids. Hydraulic design- Selection of impeller and casing dimension using industrial manuals.

UNIT-IV: THEORY OF FANS AND BLOWERS
Classification of blowers, Basics of stationary and moving air, Eulers characteristics, velocity triangles and operating pressure conditions, Equations for blowers, Losses and hydraulic efficiency, flow through impeller casing, inlet nozzle, Volute, diffusers, leakage, mechanical losses, surge and stall, Applications of blowers and fans.

UNIT-V: DESIGN OF FANS AND BLOWERS AND DESIGN OF COMPRESSORS
Design of Fans and Blowers: Rotor design airfoil theory, vortex theory, cascade effects, degree of reaction, Design procedure for selection and optimization of Blowers. Stage pressure rise, stage parameters and design parameters. Design of impeller and casing dimension in aerodynamic design.
Design of Compressors: Basic theory, classification and application, Working with enthalpy-entropy diagram, construction and approximate calculation of centrifugal compressors, impeller flow losses, slip factor, diffuser analysis, performance curves of centrifugal compressors, Basic design features of axial flow compressors; velocity triangles, enthalpy-entropy diagrams, stage losses and efficiency, work done factor, simple stage of axial flow compressors.

TEXTBOOKS:

1. Turbine, ―Compressors and Fans― S.M.Yahya, Tata Mc-Graw Hill Publishing Company, 1996R. K. Rajput, ―Fluid Mechanics and Hydraulic Machines, S. Chand
2. R. K. Bansal, ―Fluid Mechanics and Hydraulic Machines, Laxmi Publication
3. V. Ganeshan ―Gas Turbines, II edition, Tata Mc-Graw Hill Publishing Company
4. R.. Yadav, Steam and Gas Turbine‖ Central Publishing House, Allahabad

REFERENCE BOOKS:

1. Shepherd, D.G., ―Principles of Turbomachinery―, Macmillan, 1969.
2. John Tuzson, ―Centrifugal Pump Design,― John Wiley

3. Stepanff, A.J., "Blowers and Pumps ", John Wiley and Sons Inc., 196
4. Austin H. Chruch, ―Centrifugal pumps and blowers―, John Wiley and Sons, 1980.
5. Val S.Labanoff and Robert Ross, ―Centrifugal Pumps Design and Applications― Jaico P House.
6. Igori Karassik, ―Pump Hand Book,― McGraw-Hill International Edition.
7. G.K.Sahu ―Pumps― New age international publishers.

MATS UNIVERSITY, RAIPUR

Subject	:	Fatigue and Fracture Mechanics
Total Theory Periods	:	45
Total Tutorial Periods	:	15
Code	:	MTP108

UNIT-I FATIGUE OF STRUCTURES

S.N. curves - Endurance limits - Effect of mean stress, Goodman, Gerber and Soderberg relations and diagrams - Notches and stress concentrations - Neuber's stress concentration factors - Plastic stress concentration factors - Notched S.N. curves.

UNIT-II STATISTICAL ASPECTS OF FATIGUE BEHAVIOUR

Low cycle and high cycle fatigue - Coffin - Manson's relation - Transition life – cyclic strain hardening and softening - Analysis of load histories - Cycle counting techniques -Cumulative damage - Miner's theory - Other theories.

UNIT-III PHYSICAL ASPECTS OF FATIGUE

Phase in fatigue life - Crack initiation - Crack growth - Final Fracture - Dislocations -fatigue fracture surfaces.

UNIT-IV FRACTURE MECHANICS

Strength of cracked bodies - Potential energy and surface energy - Griffith's theory -Irwin - Orwin extension of Griffith's theory to ductile materials - stress analysis of cracked bodies - Effect of thickness on fracture toughness - stress intensity factors for typical geometries.

UNIT-V FATIGUE DESIGN ANDTESTINIG

Safe life and Fail-safe design philosophies - Importance of Fracture Mechanics in Turbo machineries- Application to composite materials and structures.

TEXT BOOKS

1. Prasanth Kumar – "Elements of fracture mechanics" – Wheeter publication, 1999.
2. Barrois W, Ripely, E.L., "Fatigue of aircraft structure", Pegamon press. Oxford, 1983.

REFERENCES

1. Sin, C.G., "Mechanics of fracture" Vol. I, Sijthoff and w Noordhoff International Publishing Co., Netherlands, 1989.
2. Knott, J.F., "Fundamentals of Fracture Mechanics", Buterworth & Co., Ltd., London, 1983.

MATS UNIVERSITY, RAIPUR

Subject	:	Optimization Techniques
Total Theory Periods	:	45
Total Tutorial Periods	:	15
Code	:	MTP109

UNIT- I

Single and Multivariable optimization methods, constrained optimization methods, Kuhn-Tucker conditions-Necessary & Sufficiency theorems.

UNIT- II

Linear programming - Traveling salesman problem and Transshipment problems-post optimization analysis. Integer programming all integers, mixed integer and zero-one programming

UNIT- III

Geometric programming – concept – degree of difficulty –solution of unconstrained & constrained non linear problems by geometric programming. Dynamic programming.

UNIT- IV

Energy System Simulation & optimization/Objectives/constraints, Problems formulation, Unconstrained problems, Constrained Variations, Kuhn-Tucker Conditions.

UNIT- V

Probabilistic Technique – Tradeoffs between capital & energy using Pinch Analysis. Energy-Economy models –Scenario Generation.

TEXT BOOKS

1. Rao S.S., “Optimization Theory & Applications”, Wiley Eastern 1990.
2. K. Deb, “Optimization for Engineering Design”, Prentice Hall of India, 1995.
3. Reklaitis G.V., Ravindram A., Ragsdell K.M., “Engineering Optimization methods & Application”, Wiley 1983.

REFERENCES

1. New Fville R. “Applied System Analysis”, McGraw Hill, Int. Edition 1990.
2. Stocker, W.I. “Design of Thermal System”, McGraw Hll, 1987.

MATS UNIVERSITY, RAIPUR

Subject	:	Heat Transfer and Heat Exchangers in Power Plants
Total Theory Periods	:	45
Total Tutorial Periods	:	15
Code	:	MTP110

UNIT-I

Basic Concepts in Heat Exchangers– Scientific Evolution, Basic design methods for heat exchanger – Tube in tube / double pipe Hxs, Construction Details and Heat Transfer – Types, Shell and Tube Heat Exchangers, Regenerators and Recuperators, Industrial applications. Temperature distribution and its implications, LMTD, Effectiveness, Shell and Tube Heat Exchangers – Kern Method – Bell Delware method -- The stream analysis method, Network of Hext exchangers, Plate heat exchanger, Compact heat exchanger.

UNIT-II

Flow Distribution and Stress Analysis – Effect of Turbulence, Friction factor, Pressure loss, Channel divergence. Thermal Stress in tubes, Types of failures.

UNIT-III

Design Aspects – Heat Transfer and pressure loss, Flow Configuration, Effect of Baffles, effect of Deviations from ideality, Design of Typical liquid, Gas-Gas-Liquid Heat Exchangers, Plate Heat Exchangers, Computerized methods for design and analysis of heat exchanger, Performance enhancement of heat exchanger, fouling of heat exchanger, Testing evaluation and maintenance of heat exchanger, Power plant heat exchanger, heat exchanger for heat recovery at low, medium and high temperatures.

UNIT-IV

Condensors and Evaporators Design – Design of Surface and Evaporative Condensors, Design of Shell and Tube, Plate type evaporators, Regenerators, Principles of boiler design, recuperators, matrix heat exchanger and heat pipe exchanger, Furnaces, Radiative heat exchangers, Direct contact heat exchangers – cooling towers

UNIT-V

Cooling Towers – Packings, Spray design, Selection of pumps, Fans and Pipes, Testing and Maintenance, Experimental Methods, Recent developments in heat exchangers.

References:

TEXT BOOKS

1. Process Heat Transfer, CRC Press, G F Hewuttm G L Shires and T R Bott,1994.
2. Fundamentals of Heat Exchanger Design, John Wiley & Sons., R K Shah and D P Sekulic,2003.
3. Heat Exchangers, CRC Press, A Kakac, H Liu, 2002.

REFERENCES

1. Handbook for Heat Exchangers and Tube Banks Design, D. Annaratone , Springer Verlag, 2010.
2. Compact Heat Exchangers, Pergamon, J.E. Hesselgreaves, 2001.
3. Advances in Thermal Design of Heat Exchangers, Eric M Smith, John Wiley & Sons, Ltd., 2005.
4.

MATS UNIVERSITY, RAIPUR

Subject	:	Fluid Power System
Total Theory Periods	:	45
Total Tutorial Periods	:	15
Code	:	MTP111

UNIT-I HYDRAULIC COMPONENTS

Introduction to fluid power system-Pascal's Law-Hydraulic fluids-Hydraulic pumps-Gear, Vane and Piston pumps-Pump Performance-Characteristics and Selection-actuators-valves-pressure control-flow control and direction control valves-Hydraulic accessories-Hydraulic Accumulator.

UNIT-II PNEUMATIC COMPONENTS

Introduction to Pneumatics-Compressors-types-Air treatment-FRL unit-Air dryer-Control valves-Logic valves-Time delay valve and quick exhaust valve-Pneumatic Sensors–types-characteristics and applications.

UNIT-III FLUID POWER CIRCUITS

Circuit Design Methodology-Sequencing circuits-Overlapping signals-Cascade method-KV Map method-Industrial Hydraulic circuits-Double pump circuits-Speed control Circuits-Regenerative circuits-Safety circuits-Synchronizing circuits-Accumulator circuits.

UNIT-IV ELECTRO - PNUEMATICS AND HYDRAULICS

Relay, Switches-Solenoid-Solenoid operated valves-Timer-Counter-Servo and proportional control-Microcontroller and PLC based control-Design of electro-pneumatic and hydraulic circuits.

UNIT-V APPLICATION, MAINTENANCE AND TROUBLE SHOOTING

Development of hydraulic / pneumatic circuits applied to machine tools-Presses-Material handling systems-Automotive systems-Packaging industries-Manufacturing automation-Maintenance and trouble shooting of Fluid Power circuits-Safety aspects involved.

TEXT BOOKS

1. Anthony "Esposito, Fluid Power with applications", Prentice Hall international–1997.
2. Majumdar.S.R, "Oil Hydraulics", Tata McGraw Hill, 2002.
3. Majumdar S.R, "Pneumatic systems-principles and maintenance", Tata McGraw Hill 1995.
4. Werner Deppert, "Kurt Stoll, Pneumatic Application", Vogel verlag–1986.

REFERENCES

1. John Pippenger, Tyler "Hicks, Industrial Hydraulics", McGraw Hill International Edition, 1980.
2. Andrew Parr, "Hydraulics and pneumatics", Jaico Publishing House, 2003.
3. FESTO, "Fundamentals of Pneumatics", Vol I, II, III.

MATS UNIVERSITY, RAIPUR

Subject	:	Fuel and Combustion
Total Theory Periods	:	45
Total Tutorial Periods	:	15
Code	:	MTP112

UNIT-I INTRODUCTION

History of Fuels, History of solid fuel, History of liquid fuels and gaseous fuels, Production, present scenario and consumption pattern of fuels, Fundamental definitions, properties and various

Measurements, Definitions and properties of solid fuels, Definitions and properties of liquid and gaseous fuels, Various measurement techniques.

UNIT-II SOLID FOSSIL FUEL (COAL)

Coal classification, composition and basis, Coal mining, Coal preparation and washing, Combustion of coal and coke making, Action of heat on different coal samples, Different types of coal combustion techniques, Coal tar distillation, Coal liquefaction, Direct liquefaction, Indirect liquefaction, Coal gasification.

UNIT-III LIQUID FOSSIL FUEL (PETROLEUM)

Exploration of crude petroleum, Evaluation of crude, Distillation, Atmospheric distillation, Vacuum distillation, Secondary processing, Cracking, Thermal cracking, Visbreaking, Coking, Catalytic cracking, Reforming of naphtha, Hydrotreatment, dewaxing, deasphalting, Refinery equipments.

UNIT-IV GASEOUS FUELS

Natural gas and LPG, Producer gas, Water gas, Hydrogen, Acetylene, Other fuel gases.

UNIT-V COMBUSTION TECHNOLOGY

Fundamentals of thermochemistry, Combustion air calculation, Calculation of calorific value of fuels, Adiabatic flame temperature calculation, Mechanism and kinetics of combustion, Flame properties, Combustion burners, Combustion furnaces, Internal combustion engines.

TEXT BOOKS

1. Modern Petroleum Technology, Vol 1, Upstream, Ed. by Richard A. Dave, IP, 6th ed., John Wiley & Sons. Ltd.
2. Modern Petroleum Technology, Vol 2, Downstream, Ed. by Alan G. Lucas, IP, 6th ed., John Wiley & Sons. Ltd.
3. Combustion, Irvin Glassman, 2nd ed., Academic Press.
4. Modern Petroleum Refining Processes, B.K. Bhaskar Rao, 4th ed., Oxford & IBH Publishing Co. Pvt. Ltd.

REFERENCES

1. Report on the project “Coal Combustion Study”, sponsored by Tata Tron and Steel Company Ltd., Jamshedpur.
2. Fuels Combustion and Furnaces, John Griswold, Mc-Graw Hill Book Company Inc.
3. Fuels and Combustion, Samir Sarkar, 3rd. ed Universities Press.
4. Petroleum Refinery Engineering, W.L. Nelson, 4th ed. Mc-Graw Hill Book Company.

MATS UNIVERSITY, RAIPUR

Subject	:	Design of Heat Exchangers
Total Theory Periods	:	45
Total Tutorial Periods	:	15
Code	:	MTP113

UNIT-I

Review of Heat Transfer Principles & Convection Correlation. Introduction to Heat Exchangers and classification.

UNIT-II

Basic Design Methodologies, -NTU Method AND LMTD method, Design of Double Pipe Heat Exchangers, Shell & Tube Type Heat Exchangers, TEMA, Nomenclature, j –Factors.

UNIT-III

Conventional Design Methods, Bell-Delware Method, Compact Heat Exchangers, j -Factors, Design Method, Condensers Classification and Design, Methods for Surface Condensers.

UNIT-IV

Evaporators – classification and Design Methods, Plate Type – Heat Exchangers, Regenerators.

UNIT-V

Basic Concepts of Mechanical Design of Heat Exchanger, Fixed and Floating Tube Sheet Design, Design of Expansion Bellows.

TEXT BOOKS

1. Holger Martin, “Heat Exchangers” Hemisphere Publ. Corp. Washington, 1992.
2. Kuppan, T., “Heat Exchanger Design Handbook”, Macel Dekker, Inc., N.Y. 2000.
3. Saunders, E.A.D., “Heat Exchangers – Selection Design and Con struction”, Longmann Scientific and Technical, N.Y., 1988.

REFERENCES

1. Kern, D.O., “Process Heat Transfer”, McGraw Hill, 1965.
2. Shah R.K., Subbarao, E.C., Mashelkar, R.A., “Heat Transfer Equipment Design”, Hemisphere Publ. Corp., 1988.
3. Seikan Ishigai, “Steam Power Engineering -Thermal and Hydraulic Design Principles”, Cambridge Univ. Press 1999.

MATS UNIVERSITY, RAIPUR

Subject	:	Design of Heat Transfer Equipments
Total Theory Periods	:	45
Total Tutorial Periods	:	15
Code	:	MTP114

UNIT - I

Classification of Heat Exchangers: Introduction- Recuperation & Regeneration-Tubular heat exchangers-Double pipe, Shell and Tube heat exchangers, Plate heat exchanger Exchangers-Plate fin and Tubular fin heat exchangers

Basic Design Methods of Heat Exchangers: Basic equations in Design, Overall heat transfer coefficient-LMTD method for heat exchanger analysis-Parallel flow, Counter flow, Multi pass, Cross flow heat exchanger design calculations – Effectiveness method (NTU))-Keys and London charts-Compact Heat exchangers – Heat Transfer optimization

UNIT - II DESIGN OF CONDENSERS

Types of Condensers-Air cooled condenser –Water cooled condensers-Evaporative condensers-Heat Transfer in condensers-Desuperheating-Condensing heat transfer coefficient-Condensation outside horizontal tubes-Condensation inside horizontal tubes-Water side coefficient-Fouling factor-Air side coefficient- Augmentation of condensing heat transfer coefficient-Influence of air inside condensers.

UNIT - III DESIGN OF EVAPORATORS

Types of Evaporators-Heat transfer in Evaporators-Pool boiling – Heat transfer coefficient for Nucleate pool boiling-Flow or forced convection boiling-Forced convection boiling correlations-Horizontal Vs. Vertical tube-Effect of oil in refrigerant on heat transfer-Extended surface evaporators-Cooling and dehumidifying coils-Augmentation of boiling heat transfer-Pressure drop in evaporators

UNIT - IV DESIGN OF COOLING TOWERS AND SPRAY PONDS

Classification-performance of cooling towers– analysis of counter flow cooling towers-enthalpy-temperature diagram of air and water cooling ponds- types of cooling ponds –cross flow cooling towers- procedure for calculation of outlet conditions.

UNIT - V

Cooling of Electronic Equipment: Introduction-The chip carrier-Printed circuit boards-Cooling load of Electronic equipment. **Conduction Cooling:** Conduction in chip carriers-conduction in printed circuit boards-heat frames. **Air Cooling**: Natural convection and radiation- Forced convection- Fan selection-cooling personal computers. Heat Pipes.

TEXT BOOKS

1. Heat Exchanger Design- A.P. Frass and M.N. Ozisik, John Wieley & Sons, New York.
2. Refrigeration & Air Conditioning by Dossat, Preentice Hall of India
3. Heat and mass transfer by Arora & Domkundwar, Dhanpat Rai.

REFERENCES

1. Heat Transfer – Necati Ozisik, TMG.
2. Refrigeration & Air-Conditioning by Stoecker.MGH.
3. Cooling Towers –J.D. Gurney, Maclaren (London).
4. Refrigeration & Air-Conditioning by C. P. Arora. TMH.

MATS UNIVERSITY, RAIPUR

Semester : 1st M. Tech Course
Branch : Turbo-Machinery
Subject : Advance Heat Transfer
Total Theory Periods : 45
Total Tutorial Periods : 15
Code : MTP115

UNIT-I FUNDAMENTALS

Modes of heat transfer: Conduction – Convection – Radiation.

UNIT II HEAT CONDUCTION

Factors affecting thermal conductivity of solids, liquids & gases, Generalthree-dimensional heat conduction equation in Cartesian, cylindrical & sphericalcoordinates, 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 & numericalmethods. Transient heat conduction with & without temperature gradients within thesystem, Heat flow in Semi -infinite solids. Application of heisler charts.

UNIT-IIIFREE AND FORCED CONVECTION

Convection fundamentals: Basic equations, Boundary layer concept, Dimensional analysis.

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 underdifferent situations. Empirical relations in convection heat transfer.

UNIT-IVBOILING AND CONDENSATION

Boiling & Condensation,Regimes of boiling heat transfer, Heat transfer in condensation, Drop wise & filmcondensation,Empirical equations.

UNIT-VRADIATIVE HEAT TRANSFER

Radiation heat transfer properties. Laws of thermal radiation. Shape factors.Radiation heat transfer between black, diffuse & gray surface. Electric networkmethod of solving radiation problems. Radiosity approach. Gas emission &absorption, Bulk Radiations.

REFERENCES:

1. S.P.Sukhatme, “Heat Transfer”, University Press (India), 1996.
2. J.P. Holman, “HeatTransfer”, 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.