DEPARTMENT OF MECHANICAL ENGINEERING

Scheme of Instruction and Syllabus of M.E. (Mechanical)

Specialization:

TURBOMACHINERY

Full time / Part time (2015-16)

UNIVERSITY COLLEGE OF ENGINEERING
(Autonomous)
Osmania University
Hyderabad – 500 007, Telangana, INDIA

Scheme of Instruction & Examination

M.E. (Mechanical Engineering) 4 Semesters (Full Time)

Sl. No	Subject	Hours per week		Duration (Hrs)	Max. Marks		Credits
		L/T	D/P		SEE	CIE	
Semester - I							
1.	Core	3	--	3	70	30	3
2.	Core	3	--	3	70	30	3
3.	Core / Elective	3	--	3	70	30	3
4.	Core / Elective	3	--	3	70	30	3
5.	Elective	3	--	3	70	30	3
6.	Elective	3	--	3	70	30	3
7.	Laboratory – I	--	3	3	--	50	2
8.	Seminar – I	--	3	3	--	50	2
	Total	**18**	**6**	**24**	**420**	**280**	**22**
Semester - II							
1.	Core	3	--	3	70	30	3
2.	Core	3	--	3	70	30	3
3.	Core / Elective	3	--	3	70	30	3
4.	Core / Elective	3	--	3	70	30	3
5.	Elective	3	--	3	70	30	3
6.	Elective	3	--	3	70	30	3
7.	Laboratory – II	--	3	3	--	50	2
8.	Seminar – II	--	3	3	--	50	2
	Total	**1**	**6**	**24**	**420**	**280**	**22**
Semester - III							
1.	Project+ Seminar*	--	4	4	--	**100****	**8**
Semester – IV							
1.	Dissertation	--	6	6	**200**	-	**16**

Note: Six core subjects, six elective subjects, two laboratory courses and two seminars should normally be completed by the end of semester II.

* *One project seminar presentation.*

** *50 marks to be awarded by guide and 50 marks to be awarded by viva-voice committee comprising Guide and two internal senior faculty members (subject experts)*

Scheme of Instruction & Examination

M.E. (Mechanical Engineering) 6 Semesters (Part Time)

Sl. No	Subject	Hours per week		Duration (Hrs)	Max. Marks		Credits
		L/T	D/P		SEE	CIE	
Semester - I							
1.	Core	3	--	3	70	30	3
2.	Core / Elective	3	--	3	70	30	3
3.	Elective	3	--	3	70	30	3
4.	Lab. I / Seminar – I	--	3	3	--	50	2
	Total	**9**	**3**	**16**	**210**	**140**	**11**
Semester – II							
1.	Core	3	--	3	70	30	3
2.	Core / Elective	3	--	3	70	30	3
3.	Elective	3	--	3	70	30	3
4.	Lab. I / Seminar – I	--	3	3	--	50	2
	Total	**9**	**3**	**12**	**210**	**140**	**11**
Semester – III							
1.	Core	3	--	3	70	30	3
2.	Core / Elective	3	--	3	70	30	3
3.	Elective	3	--	3	70	30	3
4.	Lab. II / Seminar – II	--	3	3	--	50	2
	Total	**9**	**3**	**12**	**210**	**140**	**11**
Semester – IV							
1.	Core	3	--	3	70	30	3
2.	Core / Elective	3	--	3	70	30	3
3.	Elective	3	--	3	70	30	3
4.	Lab. II / Seminar – II	--	3	3	--	50	2
	Total	**9**	**3**	**12**	**210**	**140**	**11**
Semester – V							
1.	Project+ Seminar*	--	6	6	--	**100****	**88**
Semester – VI							
1.	Dissertation	--	8	8	**200**	-	**16**

Note : Six core subjects, six elective subjects, two laboratory courses and two seminars should normally be completed by the end of semester IV.

* Project seminar presentation on the topic of Dissertation only

*** 50 marks to be awarded by guide and 50 marks to be awarded by viva-voice committee comprising Guide and two internal senior faculty members (subject experts)*

M. E. Mechanical Engineering(Turbomachinery)

w. e. f. 2015-2016

Syllabus Ref. No. (Code)	Subject Title	Contact hrs Per Week	Scheme of Examination		Credits
			CIE	SEE	
Core Subjects:					
ME2201	Principles of Turbo Machinery	3	30	70	3
ME2202	Fluid Flow and Gas Dynamics	3	30	70	3
ME2203	Cascade Aerodynamics	3	30	70	3
ME2204	Heat Transfer and Heat Exchangers in Power Plants	3	30	70	3
ME2205	Design of Steam Turbines	3	30	70	3
ME2206	Computational Fluid Dynamics	3	30	70	3
Elective Subjects:					
ME2207	Design of Gas Turbines	3	30	70	3
ME2208	Power Plant Steam generators	3	30	70	3
ME2401	Finite Element Techniques	3	30	70	3
ME2306	Computer Aided Modeling and Design	3	30	70	3
ME2309	Vibration Analysis and Condition Monitoring	3	30	70	3
ME2107	Mechanics of Composite Materials	3	30	70	3
ME2305	Fluid Power Systems	3	30	70	3
ME2209	Advanced Energy Systems	3	30	70	3
ME2210	Experimental Techniques in Turbomachines	3	30	70	3
ME2211	Rotor Dynamics	3	30	70	3
ME2212	Flow Induced Vibration	3	30	70	3
ME2213	Fuels and Combustion	3	30	70	3
ME2214	Design of Thermal Systems	3	30	70	3
ME2215	Design of Pumps and Compressors	3	30	70	3
ME2216	Numerical Methods	3	30	70	3
ME2001	Engineering Research Methodology	3	30	70	3
Departmental Requirements:					
ME2231	Turbo Machinery Lab (Lab – I)	2	50	-	2
ME2232	CFD Lab (Lab –II)	2	50	-	2
ME2033	Seminar-I	2	50	-	2
ME2034	Seminar-II	2	50	-	2
ME2035	Project Seminar	4	100	-	8
ME2036	Dissertation	6	150		12

CIE : Continuous Internal Evaluation SEE : Semester End Examination

ME2201

PRINCIPLES OF TURBO MACHINERY

Instructions 3 periods/week ***Duration of university Examination: 3 hours***
Credits 3 ***SEE: 70 Marks*** ***CIE: 30 Marks***

Objectives:

1. To learn classification of turbomachines
2. To calculate energy transfer through a turbomachine
3. To understand energy transfer and losses in centrifugal compressors, axial fans and steam turbines

UNIT-I

Introduction to Turbomachines. Classification of Turbomachines. Second Law of Thermo dynamics - turbine/compressor work, Nozzle/diffuser work. Fluid equations - continuity, Euler's, Bernoulli's equation and its applications. Expansion and compression processes, Reheat Factor, Preheat Factor.

UNIT-II Euler's Equation of Energy Transfer, vane congruent flow, influence of relative circulation, thickness of vanes, number of vanes on velocity triangles, slip factor, Stodola, Stanitz and Balje's slip factor. Suction pressure and net positive suction head. Phenomena of cavitation in pumps. Concept of specific speed, Shape number. Axial, Radial and Mixed Flow Machines. Similarity laws.

UNIT–III Flow through Axial flow fans. Principles of Axial fan and propeller. Application of fans for air circulation and ventilation. Stage pressure rise and work done. Slip stream and Blade Element theory for propellers. Performance and characteristics of Axial fans.

UNIT-IV Flow through Centrifugal compressors. Stage velocity triangles, specific work. forward, radial and backward swept vanes. Enthalpy entropy diagram, degree of reaction, slip factor, efficiency. Vane less and vaned diffuser systems, volute as spiral casing. Surge and stall in compressors

UNIT-V Axial turbine stages, stage velocity triangles, work, efficiency, blade loading, flow coefficient. Single stage impulse and reaction turbines, degree of reaction, 50% reaction turbine stage, Radial equilibrium and Actuator disc approach for design of turbine blades. Partial admission problems in turbines. Losses in turbo machines.

Suggested Reading:

1. S.M. Yahya, Turbines, Compreessors and Fans, Tata Mcgraw Hill.
2.Gopalakrishnan G, Prithvi Raj D, "A treatise on Turbomachines", Scitec Publications, Chennai, 2002.
3. Sheppard, Principles of Turbomachinery.
4. R.K.Turton, Principles of Turbomachinery, E & F N Spon Publishers, London & New York.
5. Balajee, Designing of Turbomachines.

ME2202

FLUID FLOW AND GAS DYNAMICS

Instructions	***3 periods/week***	***Duration of university Examination: 3 hours***	
Credits	***3***	***SEE: 70 Marks***	***CIE: 30 Marks***

Objectives:

1) To understand basic concepts of fluid motion
2) To formulate fundamental conservation equations for fluid flow.
3) To understand flow phenomena over an airfoil.
4) To study about the Compressibility effects on fluid flow properties

UNIT-I

Fluid flow: Classification of fluids. Lagrangian and Eularian Methods of Study of fluid flow. Velocity and acceleration vectors. Circulation and Vorticity. Stream lines. Stream tube. Path lines. Streak lines and Time lines. Stream function and Potential function.

UNIT-II

Basic laws of fluid flow – Continuity. Euler's and Bernoulli's equations. Incompressible and Compressible flows. Potential and viscous flows. Navier – Stoke‟s equation and applications.

UNIT-III

Flow over an airfoil – Lift and Drag coefficients. Boundary layer theory – laminar and turbulent boundary layers. Hydrodynamic and thermal boundary layer equations. Flow separation in boundary layers.

UNIT-IV

Gas dynamics: Energy equation for flow and non flow processes. Application of Steady flow energy equation for turbines, turbo-compressors, nozzles and diffusers. Adiabatic energy equation. Acoustic velocity, Mach Number. Stagnation properties. Relationships between static and stagnation properties. Various regimes of flow – Steady flow ellipse.

UNIT-V

Isentropic flow through variable area passages. Design of supersonic and subsonic nozzles and diffusers. Super sonic flows. Expansion and Shock waves. Normal and Oblique Shock waves. Prandtl-Meyer and Rankine-Hugoniot Relations. Simple problems on normal and oblique shock waves.

Suggested Reading:

1. C P Kothandaraman, R Rudramoorthy, Basic Fluid Mechanics, New Age Intl. Publishers.
2. S.M. Yahya, Fundamentals of Compressible flow, Wiley Eastern Ltd.
3. P. Balachandran,Fundamentals of compressible fluid dynamics, PHI Learning Pvt. Ltd.,
4. Zoeb Hussain, Gas Dynamics Though Problems, John Wiley and Sons.

ME2203

CASCADE AERODYNAMICS

Instructions ***3 periods/week*** ***Duration of university Examination: 3 hours***
Credits ***3*** ***SEE: 70 Marks*** ***CIE: 30 Marks***

Objectives:
1) To understand Airfoil blade nomenclature and NACA Series specifications.
2) To analyse the flow phenomena over turbine /compressor Airfoil blades /cascades.
3) To learn about application of finite difference techniques in study of flow through turbomachinery passages.

UNIT-I

Airfoil blade geometry. Blade terminology – leading and trailing edges, flow angles, blade angles, camber line, chord line, solidity, space to chord ratio, aspect ratio, Comparison of turbine and compressor blade/ cascade profiles.

UNIT-II

Fundamental Theory of Airfoils - flow around an aerofoil, pressure distribution around airfoil and lift generation. NACA series of airfoils –Calculation of coordinates of airfoils for NACA Four-Digit Series and NACA Five-Digit Series- Advantages and Disadvantages of NACA Series Airfoils and their Applications.

UNIT-III

Turbine cascade analysis – evaluation of axial, tangential, lift and drag forces. Relations for lift, drag and pressure coefficients. Losses in turbine cascade/blade passages – profile, annulus, secondary and tip clearance losses. Correlations for estimation of losses.

UNIT-IV

Compressor cascade analysis – evaluation of axial, tangential, lift and drag forces. Relations for lift, drag and pressure coefficients. Losses in compressor cascade/blade passages – profile, annulus, secondary and tip clearance losses. Correlations for estimation of losses. Effects of flow and geometrical parameters on cascade performance.

UNIT-V

Application of finite difference techniques for study of flow phenomena – first & second order accuracy relations for forward, rearward & central difference relations. Two dimensional supersonic flow through a turbo machine passage – application of Mack"s finite difference Methods, transformation of physical plane into computational plane, governing equations, primitive variables, flux variables, predictor – corrector approach for obtaining numerical solutions.

Suggested Reading:

1. J.P.Gostelow, Cascade Theory, Pergamon Press, New York
2. Charles E. Dole & James E. Lewis, Flight Theory and Aerodynamics, John Wiley and Sons.
3. J.H. Horlock, Axial Flow Compressors and Turbines.

ME2204 With effect from the Academic Year 2015 - 2016

HEAT TRANSFER AND HEAT EXCHANGERS IN POWER PLANTS

Instructions	***3 periods/week***	***Duration of university Examination: 3 hours***	
Credits	***3***	***SEE: 70 Marks***	***CIE: 30 Marks***

UNIT-I
Conduction: Two dimensional steady state problems – Cartesian and cylindrical geometries. General unsteady state heat conduction equation in cylindrical and spherical co-ordinates. Periodic and non periodic temperature variations within a semi-infinite solid within infinite wall. Extended Surfaces (Fins): Heat transfer from a straight fin (Plate) of a uniform cross section, Error in measurement of temperature in a thermometer well, Fin efficiency, Applications.

UNIT-II Convection: Approximate integral boundary layer analysis. Heat transfer in the laminar flow inside smooth tubes. Analogy between momentum and heat transfer in turbulent flow over a plane surface and turbulent flow in a tube. Empirical correlations – free convection (vertical and horizontal plates).

UNIT-III Radiation: Enclosures with black surfaces, Enclosures with gray surfaces. Numerical Methods – finite difference techniques. Gas radiation.

UNIT-IV Boiling and condensation: Boiling: Boiling phenomenon, Boiling curve, Mechanism of nucleate boiling, Stable film boiling, Forced convection boiling. Condensation: Condensation phenomenon, Film Condensation on a vertical surface, Condensation out side a horizontal tube or a tube bank, Condensation inside a horizontal tube. Drop wise Condensation. Introduction to two-phase flow: Simple momentum and energy equations.

UNIT-V Heat Exchangers: Parallel flow, counter flow and cross flow heat exchangers, multi-pass shell and tube heat exchangers and design. Plate type of heat exchangers, and Compact Heat Exchangers. Power plant heat exchangers: Condensers, Feed Water Heaters, Evaporators, Dearators, Economizer, Air Pre heaters, and their design considerations. Principles of simultaneous heat and mass transfer. Analysis of cooling towers. Case studies of heat transfer related problems in Power Plant Boilers and Turbines.

Suggested Reading:
1. Frank Kreith and S. Bohn, *Principles of Heat Transfer*, Harper and Roks Publishers, New York 1986.
2. Glen Myers, *Analytical Method in Conduction Heat Transfer*, McGraw Hill co., 1971.
3. W.M. Kays, *Convective Heat and Mass Transfer*, Tata McGraw Hill Publishing Co. Ltd., 1979.
4. J.P. Holman, *Heat Transfer*, McGraw – Hill Book Co., 1992.
5. Kern, D.Q., *Process Heat Transfer*, McGraw Hill, 1950.
6. Binay K. Dutta, *Heat Transfer,* Prentice Hall of India, 2001.

ME2205

DESIGN OF STEAM TURBINES

Instructions	***3 periods/week***	***Duration of university Examination: 3 hours***	
Credits	***3***	***SEE: 70 Marks***	***CIE: 30 Marks***

UNIT-I
Introduction. Working principles of steam turbines. Flow through impulse and reaction steam turbine stage. Theoretical steam turbine cycle and methods of improving cycle efficiency.

UNIT-II Flow analysis in steam nozzles and effect of back pressure. Design and testing of converging – diverging nozzle. Effect of area ratio on the performance of the nozzle.

UNIT-III Optimum blade speed ratio and two stage impulse wheel. Blade and stage efficiencies for multi stage steam turbines. Vortex flow and mixed flow turbines. Losses in steam turbines. Design of steam turbine blading and performance at varying loads.

UNIT-IV Design and construction of steam turbine rotor. Disc of constant strength. Stress in steam turbine rotors and blades. Material for rotor and blades.

UNIT-V Blade attachment techniques. Critical speeds and balancing of rotors, speed regulation of turbines. Static and dynamic balancing of turbogenerator sets.

Suggested Reading:
1. W.J. Kearton, *Steam Turbine Theory And Practice*, CBS Publishers, Delhi.
2. Zoeb Hussain, *Steam Turbine Theory And Design*, Tata McGraw Hill Publishers, Delhi.
3. Balje, *Turbomachinery – Theory, Design and Practice*.

ME2206

COMPUTATIONAL FLUID DYNAMICS

Instructions	***3 periods/week***	***Duration of university Examination: 3 hours***	
Credits	***3***	***SEE: 70 Marks***	***CIE: 30 Marks***

Objectives:

1. **To convert the conservation equations of fluid flow in differential form into algebraic equations and apply numerical methods to obtain solutions.**
2. **To learn the finite difference method.**
3. **To learn finite volume method and solution methodology for fluid flow problems.**

UNIT-I

Review of basic equations of fluid dynamics: Continuity, Momentum and Energy equations, Navier Stokes equations, Reynolds and Favre averaged N – S equations. Differential equations
for steady and unsteady state heat conduction. Differential equations for diffusion. Introduction to turbulence, Turbulence models-mixing length model, K- turbulence Model.

UNIT-II

Classification of PDEs – Elliptic, parabolic and hyperbolic equations. Initial and boundary value problems. Concepts of Finite difference methods – forward, backward and cent**ral difference. Errors, Consistency, Stability analysis by von Neumann. Convergence criteria.**

UNIT-III

Grid Generation- Types of grid O,H,C. Coordinate transformation, algebraic methods. Unstructured grid generation.

UNIT-IV

Finite difference solutions-Parabolic PDEs – Euler, Crank Nicholson, Implicit methods, Elliptic PDEs – Jacobi, Gauss Seidel, ADI, methods. FD- solution for Viscous incompressible flow using Stream function – Vorticity method & MAC method.

UNIT- V

Introduction to Finite volume method. Finite volume formulations for diffusion equation, convection diffusion equation. Solution algorithm for pressure velocity coupling in steady flows. Use of Staggered grids SIMPLE Algorithm.

Suggested Reading:

1. Pradip Niyogi, Chakrabartty SK, Laha M.K., „Introduction to Computational Fluid Dynamics‟, Pearson Education, 2005.
2. Muralidhar K, Sundararajan T, „Computational Fluid flow and Heat transfer‟, Narosa Publishing House, 2003.
3. Chung, T J, „Computational Fluid Dynamics‟, Cambridge University Press, 2002.
4. John D Anderson, „Computational Fluid Dynamics‟, Mc Graw Hill, Inc., 1995.
5. Patankar, S.V, „Numerical Heat transfer and Fluid flow‟, Hemisphere Publishing Company, New York, 1980.

ME2207

DESIGN OF GAS TURBINES

Instructions	***3 periods/week***	***Duration of university Examination: 3 hours***	
Credits	***3***	***SEE: 70 Marks***	***CIE: 30 Marks***

UNIT-I
Thermodynamic analysis of Gas turbine power cycles – Joule/Brayton. Open and Closed Cycles. Methods of improving cycle efficiency – Intercooling. Reheating and Regeneration.

UNIT-II Applications of Turbo Compressors (Centrifugal and axial flow) in Gas turbine power plant. Euler equation of energy transfer in a turbomachine. Design of two stage centrifugal compressor with vaneless and vaned diffusers. Design of multi stage axial flow compressors.

UNIT-III Types of combustion chambers. Combustion chamber design for modern gas turbines. Can type, annular and tube type of combustors.

UNIT-IV Analysis and design of 2-D and 3-D flow for axial flow turbines. Matching of compressor and turbine for varying load operation. Gas turbine for super charging and cryogenic applications. Small gas turbines for space applications.

UNIT-V Design and construction of Gas turbine rotors and blades. Blade materials. Blade attachment techniques. Cooling methods of turbine blades. Simple analysis of turbine blade vibrations and balancing of rotors.

Suggested Reading:
1. D.G.Wilson, *The Design of High efficiency Turbomachinery and Gas Turbines*, The MIT Press, Cambridge, U.K.
2. M.P.Boyce, *Gas Turbine Engineering hand book*, Gulf Publishing Co., New York.
3. O.E. Balje, *Turbo machines – A guide to Selection and Theory*, John Wiley & Sons, New York.
4. J.S. Rao, *Rotor Dynamics*, Wiley Eastern Publication, New Delhi.

ME2208

POWER PLANT STEAM GENERATORS

Instructions 3 periods/week ***Duration of university Examination: 3 hours***
Credits 3 ***SEE: 70 Marks*** ***CIE: 30 Marks***

UNIT-I

Introduction-steam generation, Nucleate & Film Boiling, circulation ratio, Natural, Assisted & Forced Circulation Boilers. Super Critical Boilers.

UNIT-II

Requirements in modern boilers, Types of steam generators and their construction and application, Fuels and Fuel Handling systems, for steam generators.

UNIT-III

Air-handling systems, Combustion in combustion systems with different types of fuels, combustion calculations, Once-thro‟ boilers, Fludised bed combustion boilers, Cyclone furnace boilers.

UNIT-IV

Furnace sizing, Burner selection and design combined cycle power plant steam generators, Emissions from steam generators and its control.

UNIT-V

Boiler maintenance, safety regulation and inspection, Ash handling Case study of typical modern boiler systems.

Suggested Reading:

1. W.J. Kearton, *Steam Turbine Theory and Practice*, CBS Publishers.
2. D.A. Relay, *Waste Heat Recovery System*.
3. I.G.C. Drydin, *The Efficient Use of Energy*.
4. H.V. Jadhav, *Energy and Environment*, Himalaya Publishing House, Mumbai.
5. Allen B. Gill, *Power Plant Performance*, Butter Worths, U.K.

ME2401

FINITE ELEMENT TECHNIQUES

Instructions	***3 periods/week***	***Duration of university Examination: 3 hours***	
Credits	***3***	***SEE: 70 Marks***	***CIE: 30 Marks***

Objectives:

- *To understand the theory and application of the finite element method for analyzing structural systems.*
- *To learn Approximation theory for structural problems as the basis for finite element methods.*
- *To learn formulations for a variety of elements in one, two, and three dimensions.*
- *To understand modeling and analysis of structures using planar, solid, and plate elements.*

UNIT-I

Introduction to Finite Element Method of solving field problems. Stress and Equilibrium. Boundary conditions. Strain-Displacement relations. Stress-strain relations. One Dimensional Problem: Finite element modeling. Local, natural and global coordinates and shape functions. Potential Energy approach : Assembly of Global stiffness matrix and load vector. Finite element equations, treatment of boundary conditions. Quadratic shape functions.

UNIT-II

Analysis of trusses and frames: Analysis of plane truss with number of unknowns not exceeding two at each node. Analysis of frames with two translations and a rotational degree of freedom at each node. Analysis of Beams: Element stiffness matrix for two noded, two degrees of freedom per node for beam element.

UNIT-III

Finite element modeling of two dimensional stress analysis problems with constant strain triangles and treatment of boundary conditions. Two dimensional four noded isoparametric elements and numerical integration. Finite element modeling of Axisymmentric solids subjected of axisymmetric loading with triangular elements. Convergence requirements and geometric isotropy.

UNIT-IV

Steady state heat transfer analysis: One dimensional analysis of a fin and two dimensional conduction analysis of thin plate. Time dependent field problems: Application to one dimensional heat flow in a rod. Dynamic analysis: Formulation of finite element modeling of Eigen value problem for a stepped bar and beam. Evaluation of Eigen values and Eigen vectors. Analysis of a uniform shaft subjected to torsion using Finite Element Analysis.

UNIT-V

Finite element formulation of three dimensional problems in stress analysis. Finite Element formulation of an incompressible fluid. Potential flow problems Bending of elastic plates. Introduction to non-linear problems and Finite Element analysis software.

Suggested Reading:

1. Tirupathi R Chandrupatla and Ashok. D. Belegundu, *Introduction of Finite Element in Engineering,* Prentice Hall of India, 1997.
2. Rao S.S., *The Finite Element Methods in Engineering,* Pergamon Press, 1989.
3. Segerland. L.J., *Applied Finite Element Analysis,* Wiley Publication, 1984. 4. Reddy J.N., *An Introduction to Finite Element Methods,* Mc Graw Hill Company, 1984.

ME2306

COMPUTER AIDED MECHANICAL DESIGN AND ANALYSIS

Instructions	***3 periods/week***	***Duration of university Examination: 3 hours***	
Credits	***3***	***SEE: 70 Marks***	***CIE: 30 Marks***

Objectives:

- To develop students knowledge and understanding of Bending of Plates.
- To understand the basics of designing pressure vessels against internal and external pressure loads. To understand the effect of thermal stress on pressure vessel
- To understand the phenomenon of buckling in pressure vessels and usage of various methods available to prevent buckling of pressure vessels.
- To understand the importance of numerical methods in solving multi degree freedom dynamic analysis problems.

To understand various numerical methods available for solving eigen values problems

UNIT-I

Stresses in flat plates: Introduction, Bending of plate in one direction, Bending of plate in two perpendicular directions, Thermal stresses in plates, Bending of circular plates of constant thickness, Bending of uniformly loaded plates of constant thickness.

UNIT-II

Design of pressure Vessels: Introduction and constructional features of pressure vessels, stresses in pressure vessels, shrink fit stresses in built up cyliners, autofrettage of thick cylinders, thermal stresses and their significance. Stress concentration at a variable thickness, thickness transistion in a cylindrical vessel, about a circular hole, elliptical openings, reinforcement design

UNIT-III

Buckling in vessels: Buckling phenomenon – Elastic Buckling of circular ring and cylinders under external pressure – collapse of thick walled cylinders or tubes under external pressure – Effect of supports on Elastic Buckling of Cylinders – Buckling under combined External pressure and axial loading.

UNIT-IV

Eigen Value Problems: Properties of Eigen values and Eigen Vectors, Torsional, Longitudinal vibration, lateral vibration, Sturm sequence. Subspace iteration and Lanczo's method, Component mode synthesis, Eigen value problems applied to stepped beams and bars.

UNIT-V

Dynamic Analysis: Direct integration method, Central difference method, Wilson-θ method, Newmark method, Mode superposition, Single degree of freedom system response, Multi degree of freedom system response, Rayleigh damping, Condition for stability.

Suggested Reading:

1. John, V. Harvey, Pressure Vessel Design: Nuclear and Chemical Applications, Affiliated East West Press Pvt. Ltd., 1969.
2. V. Rammurti, Computer Aided Mechanical Design and Analysis, Tata Mc Graw Hill-1992.
3. Abdel-Rehman Ragab & Salah Edin Bayoumi, Engineering Solid Mechanics, CRC Press, 1998
3**. Annaratone,** Donatello,Pressure Vessel Design, springer verlag, 2007
4.Henry bednar, Pressure vessel Design handbook, Krieger Pub Co; 2 edition.
5.Chandrasekhra, Theory of Plates, University Press, 2001

ME2309

VIBRATION ANALYSIS AND CONDITION MONITORING

Instructions	***3 periods/week***	***Duration of university Examination: 3 hours***	
Credits	***3***	***SEE: 70 Marks***	***CIE: 30 Marks***

Objectives

- Fully understand importance of vibrations in mechanical design of machine parts that operate under vibratory conditions.
- Able to write differential equation of motion of vibratory system and understand free and forced modes of vibration
- Able to obtain linear vibratory models of dynamic systems of varying complexity (SDOF, MDOF)
- Able to understand the various condition monitoring techniques available in the literature.
- Able to understand the various devices available to record interpret and understand the vibration data.

UNIT-I

Causes and effects of vibration. Vibrations of Single Degree of freedom systems. Free, Damped and Forced vibrations

UNIT-II

Two Degree of freedom systems. Bending vibrations of two degree of freedom systems, Steady state and transient characteristics of vibration, vibration absorber and vibration isolation.

UNIT-III

Multi degree of freedom systems: Dunkerley method, Rayleigh method, stodola method and holzers method. Modal analysis.

UNIT-IV

Introduction to Condition Monitoring, Failure types, investigation and occurrences. Causes of failure, Vibration measuring instruments, vibration transducers, signal conditioning elements. Display and recording elements. Vibration meters and analyzers. Condition Monitoring through vibration analysis. Frequency analysis, Filters, Vibration signature of active systems, vibration limits and standards.

UNIT-V

Contaminant analysis, SOAP and other contaminant monitoring techniques.

Special vibration measuring techniques - Change in sound method, Ultrasonic measurement method, Shock pulse measurement, Kurtosis, Acoustic emission monitoring, Cepstrum analysis, Modal analysis, critical speed analysis, Shaft –orbit & position analysis.

Suggested Readings:

1. Rao S .S Mechanical Vibrations , 5th Edition, Prentice Hall, 2011
2. V.P.Singh, Mechanical vibrations, Dhanpat Rai Publications, 2015
3. Collacott, R.A., *Mechanical Fault Diagnosis and Condition Monitoring,* Chapman & Hall, London, 1982.
4. John S. Mitchell, *Introduction to Machinery Analysis and Monitoring,* Penn Well Books, Penn Well Publishing Company, Tulsa, Oklahoma, 1993.
5. J S Rao, Vibration condition monitoring of machines, CRC Press, 2000
6. Nakra, B.C. Yadava, G.S. and Thuested, L., Vibration Measurement and Analysis, National Productivity Council, New Delhi, 1989.

ME2107

MECHANICS OF COMPOSITE MATERIALS

Instructions	***3 periods/week***	***Duration of university Examination: 3 hours***	
Credits	***3***	***SEE: 70 Marks***	***CIE: 30 Marks***

UNIT-I

Introduction: Fibres, Matrix materials, interfaces, polymer matrix composites, metal matrix composites, ceramic matrix composites carbon fibre composites.

UNIT-II

Micromechanics of Composites: Mechanical properties: Prediction of Elastic constant, micromechanical approach, Halpin-Tsai equations, Transverse stresses. Thermal properties: Hygrothermal stresses, mechanics of load transfer from matrix to fibre.

UNIT-III

Macromechanics of Composites: Elastic constants of a lamina, relations between engineering constants and reduced stiffness and compliances, variation of lamina properties with orientation, analysis of laminated composites, stresses and strains with orientation, inter-laminar stresses and edge effects. Simplified composite beam solutions. Bending of laminated beams.

UNIT-IV

Strength, fracture, fatigue and design: Tensile and compressive strength of unidirectional fibre composites, fracture modes in composites: Single and multiple fracture, de-bonding, fibre pullout and de-lamination failure, fatigue of laminate composites. Effect of variability of fibre strength. Strength of an orthotropic lamina: Max stress theory, max strain criteria, maximum work (Tsai-Hill) criterion, quadratic interaction criteria. Designing with composite materials.

UNIT-V

Analysis of plates and stress: Plate equilibrium equations, Bending of composite plates, Levy and Navier solution for plates of composite materials. Analysis of composite cylindrical shells under axially symmetric loads.

Suggested Reading:

1. Jones, R.M., *Mechanics of Composite Materials, Mc Graw Hill Co., 1967.*

2. Calcote, L.R., *The Analysis of Laminated Composite Structures,* Van Nostrand, 1969.

3. Whitney, I.M. Daniel, R.B. Pipes, *Experimental Mechanics of Fibre Reinforced Composite Materials,* Prentice Hall, 1984.

4. Hyer, M.W., *Stress Analysis of Fibre Reinforced Composite Materials,* Mc Graw Hill Co., 1998. 5. Carl. T. Herakovich, *Mechanics of Fibrous Composites,* John Wiley Sons Inc., 1998.

ME2305

FLUID POWER SYSTEMS

Instructions	***3 periods/week***	***Duration of university Examination: 3 hours***	
Credits	***3***	***SEE: 70 Marks***	***CIE: 30 Marks***

Objectives

- The course will develop the students' knowledge and understanding of hydraulic and pneumatic devices and systems.
- The students should be able to understand the principles of operation and the design details of hydraulic pumps, motors, valves, actuators, and systems.
- The student should be able to analyze both the steady-state and the dynamic performance of individual hydraulic components and systems.
- The student should also be able to relate the theory with the practical applications of these principles

UNIT - I

Advantages and Disadvantages of Fluid control, Types of Hydraulic Fluids, physical, chemical and thermal properties of hydraulic fluids, selection of hydraulic fluid, fluid flow fundamentals. Hydraulic Pumps and Motors: Basic Types and constructions, ideal pump and motor analysis, Performance curves and parameters

UNIT - II

Hydraulic Control Valves- Valve configurations, general valve analysis, critical center, open center, three way spool valve analysis and Flapper valve analysis, pressure control valves, single and two stage pressure control valves, flow control valves, introduction to electro hydraulic valves.

UNIT - III

Hydraulic Power Elements: Valve controlled motor, valve controlled piston, three way valve controlled piston, pump controlled motor, pressure transients in power elements.

UNIT - IV

Characteristics of Pneumatics, Applications of Pneumatics, Basic Pneumatic elements, Pneumatic servo mechanisms, pneumatic servo, ram equations, load sensitivity, method of stabilization, stabilization using auxiliary tanks. Some practical aspects of servo testing and design

UNIT - V

Control of pressure and speed in Hydraulic and Pneumatic Systems, Fluidics:proportional amplifier, bistable amplifier, vortex amplifier, turbulence amplifier, impact modulator, Boolean algebra, fluid logics,manipulation of logic expressions, special circuits and sequential circuits.

Suggested Reading:

1 Herbert E. Merritt, “Hydraulic Control Systems”, John Wiley & Sons, 1967.
2 D McCloy & H R Martin,” The control of fluid power” Longman publications.1980
3 Anthony Esposito, “Fluid power with applications”, Prentice Hall, 7th Edition, 2002.
4 Arthur Akers, Max Gassman, Richard Smith, “Hydraulic Power System Analysis”, Taylor and Francis Group, 2006.
5 John Pippenger & Tyler Hicks, “Industrial Hydraulics”, 3rd edition McGraw Hill , 1979
6.A.B. Goodwin, Fluid Power Systems, Macmillan, 1976.

ME2209

ADVANCED ENERGY SYSTEMS

Instructions	*3 periods/week*	*Duration of university Examination: 3 hours*	
Credits	*3*	*SEE: 70 Marks*	*CIE: 30 Marks*

Objectives:

- To explain the concept of various forms of renewable energy sources.
- To design renewable/hybrid energy systems that meet specific energy demands, are economically feasible and have a minimal impact on the environment.
- Explain the concepts of waste heat recovery, Fluidization and applications.
- The students will have sufficient knowledge on working of various fuel cells.

UNIT-I

Solar Energy: Solar radiation – measurement, collection and storage, Solar Thermal Systems, Design of flat plate and parabolic concentrating collectors, Solar power plants. Photo voltaic power systems. Application of SPV.

UNIT-II

Wind Energy: Estimation of wind energy potential. Horizontal and Vertical axis wind turbine rotors. Aerodynamic design considerations for wind rotor blades. Wind electric generators-operation and control. Aero generators for battery charging.

UNIT-III

Biomass Energy: Sources of biomass. Biomass for Energy production. Methane production. Biomass energy conversion technologies. Use of Biomass gasifier, Types of gasifiers. Biomass Power generation using agricultural residues. Introduction of Hybrid energy systems.

UNIT-IV

Waste Heat Recovery: Principles and Devices - Regenerators and Recuperators. Analysis of heat recovery systems. Design of waste heat recovery boilers. Combined cycle power plants based on waste heat recovery.

UNIT-V

Fuel Cell Technology: Introduction, Classification of fuel cells, Operating principles, Thermodynamic Aspects of Electrochemical Energy Conversion, Electrochemical kinetics, Performance of fuel cells, fuel cell components - Alkaline Fuel Cells, (AFC), Solid Oxide Fuel Cells (SOFC), Proton Exchange Membrane Fuel Cells (PEMFC), Characteristics of fuel cells.

Suggested Reading:

1. J.A. Duffire and W.A. Beckmen, *Solar Energy Thermal Processes*, John Wiley & Sons Inc, New York, 2006
2. Paul Gipe, *Wind Energy Comes of Age*, John Wiley & Sons Inc, New York, 1995
3. N.H Ravindranath and D O Hall, *Bio Mass, Energy and Environment*, Oxford University Press, 1995
4. D.A. Relay, E & F.N.Span, *Waste Heat Recovery System,* London, 1979
5. J. Larminie and A. Dicks, Fuel Cell Systems Explained, 2nd Edition, Wiley, 2003

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ME2210

EXPERIMENTAL TECHNIQUES IN TURBO MACHINES

Instructions	***3 periods/week***	***Duration of university Examination: 3 hours***	
Credits	***3***	***SEE: 70 Marks***	***CIE: 30 Marks***

Objectives

- To develop innovative techniques to solve turbomachinery problems.
- To apply a deep working knowledge on instruments for experiments in areas related to turbomachinery and thermal systems.
- To design and implement new experiments in turbomachinery.

UNIT-I

Experiment planning, experiment design factors. Classification of measurement techniques. Conventional techniques for measurement of Flow, Pressure, Temperature and Velocity in turbomachinery passages.

UNIT-II

Temperature measuring devices – Thermo electric thermometry and pyrometry. Instantaneous pressure measurement using pressure transducers, Pitot tube, probes,. Boundary layer measurement. Calibration of probe.

UNIT-III

Wind tunnels: Schematic layout of wind tunnel with test section, subsonic, transonic and supersonic wind tunnels. Measurement of turbulence using a Hot wire anemometer and Laser Doppler anemometer.

UNIT-IV

Calibration methods and signal processing techniques. General data acquisition system Data transmission, A/D and D/A conversion, Recorders with digital display. Data collection and storage.

UNIT-V

Flow measurement instruments, Flow Visualization techniques – conventional and optical methods. Radar Doppler and Laser velocimeter. Brief description of error and uncertainty analysis.

Suggested Reading:

1. R.C.Dean, Aerodynamics Measurements, Gas Turbine Laboratory, Massachusetts Institute of Technology, Cambridge, 1953.
2. David Japikse (Editor),Advanced Experimental Techniques In Turbomachinery, December 1986.
3. J. P. Holman,Experimental Methods for Engineers, Seventh Edition,McGraw-Hill, 2007.
4. Lewis Beckwith and Buck, Mechanical Measurements,Second Edition,Addison Wesley, 1973.
5. A.K.Tayal,Instrumentation, Mechanical Measurements and Control: 2nd Edition,Galgotia Publications Pvt Ltd 1999

ME2211

ROTOR DYNAMICS

Instructions ***3 periods/week*** ***Duration of university Examination: 3 hours***
Credits ***3*** ***SEE: 70 Marks*** ***CIE: 30 Marks***

UNIT-I

Single degree of freedom system – Free vibrations. Damped vibrations and forced vibrations, Two degree of freedom systems – Undamped vibration, absorbers, Forced Damped vibrations, Vibration isolation.

UNIT-II

Close coupled systems – Eigenvalue problem. Orthogonality of mode shapes. Modal analysis Critical speeds.

UNIT-III

Vibrations of multi rotor systems – Matrix method, Influence coefficient methods, Transfer matrix analysis and Holzers method.

UNIT-IV

Torsional vibrations in rotating machinery – Equivalent discrete system, transient response, branched system.

UNIT-V

Out-of-rotors in rigid supports, simply supported rotor with overhangs. Gyroscopic effects. Rotor mounted on fluid film bearings – Transfer matrix analysis of turbine rotor by distributed elements, Dual rotor system analysis. Balancing of rotors.

Suggested Reading:

1. J.S. Rao, *Rotor dynamics*.

2. J.S. Rao, K. Gupta, *Mechanical Vibrations*.

ME2212

FLOW INDUCED VIBRATIONS

Instructions	***3 periods/week***	***Duration of university Examination: 3 hours***	
Credits	***3***	***SEE: 70 Marks***	***CIE: 30 Marks***

UNIT-I

Single degree system with external excitation. Two degree System, Modal analysis, Principal coordinates.

UNIT-II Non dimensional variables, Vortex induced vibrations, Vortex wake of a stationary cylinder,

Strouhal‟s number, Wake oscillatory model, Correlation model, Reduction of vortex induced vibrations.

UNIT-III

Stall flutter, Stability of one degree and two degree freedom systems. Response of one degree and two degree of freedom systems, Galloping of a beam and cable and reduction of galloping vibrations.

UNIT-IV

Vibrations induced by oscillatory flow, solution of linearised equations, Oscillatory flow with mean zero flow and with mean flow, Sound induced by vortex shedding.

UNIT-V

Vibrations of pipe containing fluid flow, Vibrations of cantilever and pinned-pinned pipe, Pipe whip.

Suggested Reading:

1. Robert D. Blevines, *Flow Induced Vibration*, Van Nostrand Reinhold Company, 1977

ME2213

FUELS AND COMBUSTION

Instructions ***3 periods/week*** ***Duration of university Examination: 3 hours***
Credits ***3*** ***SEE: 70 Marks*** ***CIE: 30 Marks***

UNIT-I
Introduction: General, Conventional energy resources, Solar energy, Nuclear power, Energy from biomass, Wind power, Tidal power, Geothermal energy, Energy survey for India, Rocket Fuels, Definitions, Units, Measures.

UNIT-II
Solid Fuels: General, Biomass, Peat, Lignite or Brown Coal, Sub-bituminous Coal or Black Lignite, Bituminous Coal, Semi-anthracite, Anthracite, Cannel coal and Boghead coal, Natural coke (Jhama)/SLV fuel, Origin of coal, Composition of coal, Analysis and properties of coal, Action of heat on coal, Oxidation of coal, Hydrogenation of coal, Classification of coal. Processing of Solid Fuels: General Coal preparation, Storage of coal, Coal carbonization, Briquetting of solid fuels, Liquefaction of solid fuels.

UNIT-III
Liquid Fuels : General, Petroleum, Origin of Petroleum, Petroleum production, Composition of petroleum, Classification of petroleum, Nature of Indian crude‟s, Petroleum processing, Important petroleum products, Properties and testing of petroleum and petroleum products, Petroleum refining in India, Liquid fuels from sources other than petroleum, Gasification of liquid fuels, Storage and handling of liquid fuels.

UNIT-IV
Gaseous fuels: General, Types of gaseous fuels, Natural gas, Methane from coal mines, Producer gas, Water gas, Carbureted water gas, Complete gasification of coal, Underground gasification of coal, Coal gas, Blast furnace gas, Gases from biomass, Refinery gases, Liquefied petroleum gases (LPG), Oil gasification, Cleaning and purification of gaseous fuels.

UNIT-V
Combustion Process (Stoichiometry and Thermodynamics): Combustion Stoichiometry : General, Examples, Rapid methods of combustion stoichiometry. Combustion Thermodynamics : General Combustion Process (Kinetics): Nature of combustion process, Types of combustion processes, Mechanism of combustion reaction, Spontaneous Ignition Temperature (SIT), Velocity of flame propagation, Limits of inflammability, Structure of flame, Flame stability, Kinetics of liquid fuel combustion, Kinetics of solid fuel combustion. Combustion Applications: General, Gas burners, Oil burners, Coal burning equipment.

Suggested Reading:
1. Loftness, R.L., *Energy hand book*, New York, Van Nostrand 1998.
2. Wilson, P.J. and J.H. Wells, *Coal, Coke and Coal Chemicals,* New York : McGraw-Hill, 1960.
3. Williams, D.A. and G. James, *Liquid Fuels*, London Pergamon, 1963.
4. *Gas Engineers Handbook,* New York : Industrial Press, 1966.
5. Minkoff, G.J., and C.F.H. Tipper, *Chemistry of Combustion Reaction,* London Butterworths, 1962.
6. Samir Sarkar, *Fuels & Combustion*, Orient Long man 1996.

ME2214

DESIGN OF THERMAL SYSTEMS

Instructions	***3 periods/week***	***Duration of university Examination: 3 hours***	
Credits	***3***	***SEE: 70 Marks***	***CIE: 30 Marks***

UNIT-I

Engineering Design : Introduction – Need – Criteria of Success – Probability of success – Market analysis – Feasibility – R&D – Iteration – Optimization of operation – Technical design. Designing a Workable System: Workable and optimum system – Design of a Food Freezing Plant – Preliminaries to the study of Optimization. Economics : Interest – lump sum, Compounded annually – lump sum Compounded more often than annually – Compound – amount factor (f/p) and present – worth factor (p/f) Future worth of a uniform series of amounts – Present worth of a uniform series of amounts – Gradient present work factor – Bonds – Shift in time of a series – Evaluating potential investments. Taxes – Depreciation – Influence of Income Tax.

UNIT-II

Modeling Thermal Equipment: Selecting Vs. Simulating a heat exchanger – Binary solutions – Temperature – Concentration – Pressure Characteristics – Developing T Vs. – x diagram – condensation of a Binary mixture Single – Stage distillation – Rectification – Pressure drop and pumping power – Turbo machinery. System Simulation : Classes of simulation – Sequential and simultaneous calculations – Simulation of a gas Turbine system.

UNIT-III

Optimization: Levels of Optimization – Optimization procedures – Lagrange Multipliers – Search Methods Dynamic Programming – Geometric Programming, Linear Programming.

UNIT-IV

Thermodynamic Properties Modeling : The form of the equation – P-V-T equations – P-T relation for saturation conditions. P/f density of liquid. The clayperon equation – Maxwells relations.

UNIT-V

Dynamic Behavior of Thermal Systems: Calculus Methods of Optimization – Calculus of variations and Dynamic Programming – Probabilistic Approaches to design.

Suggested Reading:

1. Stoecker, W.F., *Design of Thermal Systems*, McGraw-Hill Book Company, 1987.

ME2215

DESIGN OF PUMPS AND COMPRESSORS

Instructions	***3 periods/week***	***Duration of university Examination: 3 hours***	
Credits	***3***	***SEE: 70 Marks***	***CIE: 30 Marks***

UNIT-I

Introduction to pumps and compressors. Characteristics of working fluids, Fluid mechanics concepts and governing laws of fluid flow.

UNIT-II

Pumps – various components and their functions. Classification of pumping systems – based on the applications and working fluids. Design of pumps – data required for the design of pump and design calculations. Selection of the drive – Types of drives, their behavior and advantages, Selection of the pumps – types of pumps. Selection of piping and other components. Development of a schematic layout of the piping system.

UNIT-III Operation and maintenance – installation of pumping system. Testing of the pumping systems – Various methods based on the working fluid, drive and pump etc., Maintenance of the pumps – Prediction and correction methods, Factors affecting the maintenance and their evaluation.

UNIT-IV Rotary compressor system – various components and their functions. Classification of compressors. Design of compressor – data and analysis. Characteristics of the compressors. Selection of the drive and compressors. Development of the schematic layout of the compressor system.

UNIT-V Design of impeller, Types of impellers – centrifugal and axial. Design of a diffuser – Vaneless and vaned diffuser. Types of casings, casing design. Performance characteristics of turbo compressors.

Suggested Reading:

1. S.M. Yahya, *Turbines, Compressors and Fans,* Tata McGraw Hill Publishing Co.
2. Val.S. Lobanoff and Robert R. Ross, *Centrifugal Pumps – Designs and Application*, Jaico book publishing Co.

ME2216

NUMERICAL METHODS

Instructions ***3 periods/week*** ***Duration of university Examination: 3 hours***
Credits ***3*** ***SEE: 70 Marks*** ***CIE: 30 Marks***

UNIT-I

Solving linear sets of equations Gauss Elimination, LV Decomposition, Matrix Inversion, Scalar Tridiagonal Matrix, Thomas Algorithm, Gauss Seidel Method, Secant Method

UNIT-II

Solving nonlinear sets of equations Minimization of function, Newton's Method, Quasi-Newton Method, Steepest Descent Method, Eigen Values & Vectors.

UNIT-III

Interpolation & Polynomial Approximation Least Squares Method, Lagrange Interpolation, Hermite Interpolation, Cubic Spline Interpolation, Chebeshev Polynomials & Series

UNIT-IV

Numerical Differentiation & Integration Numerical Differentiation, Richardson's Extrapolation, Definite & Indefinite Integrals, Simpson's Rule, Trapezoid Rule, Gaussian Quadrature

UNIT-V

Ordinary Differential Equations: First and Higher Order Taylor Series, First order Runge-kutta Method, Fourth order Runge-kutta Method, Stiff Equations, Errors, Convergence Criteria.

Suggested Reading:

1. Cheney E. Ward, Kincaid D.R., Numerical Methods and Applications, 2008, Cengage Learning
2. Gerald C.F., Wheatley P.O., Applied Numerical Analysis, 7th Ed, Pearson Education.
3. Burden R.L., Faires J.D., Numerical Analysis: Theory and Applications, 2005, Cengage Learning.
4. Chapra S.C., Canale R.P., Numerical Methods for Engineers, 4th Ed, Tata McGraw Hill.
5. Mathews J.H., Fink K.D., Numerical Methods using MA TLAB, 4th Ed, Pearson Education.
6. Press W.H., Taukolsky S.A., Vetterling W.T., Flannery B.P., Numerical Recipes in C++, 2nd Ed, Cambridge University Press.

ME2001

ENGINEERING RESEARCH METHODOLOGY

Instructions	***3 periods/week***	***Duration of university Examination: 3 hours***	
Credits	***3***	***SEE: 70 Marks***	***CIE: 30 Marks***

Objectives:

1. To learn the research types, methodology and formulation.
2. To know the sources of literature, survey, review and quality journals.
3. To understand the research design for collection of research data.
4. To understand the research data analysis, writing of research report and grant proposal.

Unit - I

Research Methodology: Objectives and Motivation of Research, Types of Research, Research Approaches, Significance of Research, Research Methods verses Methodology, Research and Scientific Method, Important of Research Methodology, Research Process, Criteria of Good Research, Problems Encountered by Researchers in India, Benefits to the society in general.

Defining the Research Problem: Definition of Research Problem, Problem Formulation, Necessity of Defining the Problem, Technique involved in Defining a Problem.

Unit - II

Literature Survey: Importance of Literature Survey, Sources of Information, Assessment of Quality of Journals and Articles, Information through Internet. **Literature Review**: Need of Review, Guidelines for Review, Record of Research Review.

Unit - III

Research Design: Meaning of Research Design, Need of Research Design, Feature of a Good Design Important Concepts Related to Research Design, Different Research Designs, Basic Principles of Experimental Design, Developing a Research Plan, Design of Experimental Set-up, Use of Standards and Codes.

Unit - IV

Data Collection: Collection of primary data, Secondary data, Data organization, Methods of data grouping, Diagrammatic representation of data, Graphic representation of data. Sample Design, Need for sampling, some important sampling definitions, Estimation of population, Role of Statistics for Data Analysis, Parametric V/s Non Parametric methods, Descriptive Statistics, Measures of central tendency and Dispersion, Hypothesis testing, Use of Statistical software.

Data Analysis: Deterministic and random data, Uncertainty analysis, Tests for significance: Chi-square, student's t-test, Regression modeling, Direct and Interaction effects, ANOVA, F-test, Time Series analysis, Autocorrelation and Autoregressive modeling.

Unit - V

Research Report Writing: Format of the Research report, Synopsis, Dissertation, Thesis its Differentiation, References/Bibliography/Webliography, Technical paper writing/Journal report writing, making presentation, Use of visual aids. **Research Proposal Preparation**: Writing a Research Proposal and Research Report, Writing Research Grant Proposal.

Suggested Reading:

1. C.R Kothari, Research Methodology, Methods & Technique; New Age International Publishers, 2004
2. R. Ganesan, Research Methodology for Engineers, MJP Publishers, 2011
3. Ratan Khananabis and Suvasis Saha, Research Methodology, Universities Press, Hyderabad, 2015.
4. Y.P. Agarwal, Statistical Methods: Concepts, Application and Computation, Sterling Publs., Pvt., Ltd., New Delhi, 2004
5. Vijay Upagade and Aravind Shende, Research Methodology, S. Chand & Company Ltd., New Delhi, 2009
6. G. Nageswara Rao, Research Methodology and Quantitative methods, BS Publications, Hyderabad, 2012.

ME2231

TURBOMACHINARY LABORATORY

Instructions ***3 periods/week***
Credits ***2*** ***CIE: 30 Marks***

Objectives:

- To get exposure on fluid flow parameters/properties measurement methods.
- To learn about the use of instrumentation in fluid flow devices
- To gain knowledge about the practical applications of course subjects.
- To understand the working principles of devices used in turbo machinery systems..
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List of Experiments:

1) Determination of static pressure distribution on a turbine blade surface at mid span on Low speed wind tunnel.
2) To Study downstream wake profile of a turbine cascade at mid span on Low speed wind tunnel.
3) To Study downstream wake profile of a compressor cascade at mid span on Low speed wind tunnel.
4) Determination of Overall heat transfer coefficient in parallel and counter flow on Finned Tube Heat Exchanger
5) Determination of Overall heat transfer coefficient in parallel and counter flow on Shell and Tube Heat Exchanger
6) Study on performance of Centrifugal blower with forward swept blades.
7) Study on performance of Centrifugal blower with backward swept blades.
8) Study on performance of Centrifugal blower with radial blades.
9) Unsteady state Heat Transfer.
10) Thermal Conductivity of Liquid.
11) Experiments on Convergent Divergent Subsonic Nozzle.
12) To estimate the I-V and P-V characteristics of series and parallel combination of Solar Photovoltaic modules.
13) Workout power flow calculations of standalone Solar Photovoltaic system of DC and AC load with battery.

ME2232

COMPUTATIONAL FLUID DYNAMICS LABORATORY

Instruction 3 Periods/week CIE: 50 Marks
Credits: 2

Objectives:

1. To learn how to model physical problem in CFD software
2. To learn geometric modeling, meshing and boundary conditions settings to solve the problem
3. To learn post processing of results and analyzing the results

Experiments:

1. Introduction to CFD – Pre Processor, Solver, Post Processor

2. Ansys Work bench – Modelling tools

3. Ansys Work Bench – Grid Generation

4. Ansys CFX pre – Properties of fluids, Boundary Conditions

5. Ansys Solver, Post processor

6. Exercise 1 : Flow through a Nozzle – Modeling, Grid generation

7. Exercise 1 : Flow through a Nozzle – Pre, Solver, Post Processor

8. Exercise 2: Flow past a cylinder – Modeling, Grid generation

9. Exercise 2: Flow past a cylinder – Pre, Solver, Post Processor

10. Exercise 3 : Static Mixer – Modeling, Grid generation

11. Exercise 3 : Static Mixer – Pre, Solver, Post Processor

12. Exercise 4 : Flow Mixing in a pipe bend – Modeling, Grid generation

13. Exercise 4 : Flow Mixing in a pipe bend - Pre, Solver, Post Processor