Curriculum

M. Tech. Mechanical (Thermal Engineering) Program

School of Technology

Pandit Deendayal Petroleum University

Course Structure of M. Tech. Mechanical (Thermal Engineering) Approved in 2018-19 and w.e.f. Admission Batch: 2019

Programme Educational Objectives (PEOs):

1. To prepare graduates with sound fundamental knowledge and futuristic research in field of thermal engineering and to make them capable of effectively analyzing and solving the problems associated in this field.
2. To prepare the graduates with core competency to be successful in industry or academia or research laboratory and motivate them to pursue higher studies in interrelated areas.
3. To prepare lifelong learner graduates by providing an academic and research environment for their successful professional career as well as to peruse higher education.
4. To prepare graduates with leadership qualities, effective communication skills, professional and ethical values.

Program Outcomes (POs)

1. **Engineering Knowledge:** Acquire advanced knowledge of thermal engineering principles and modelling methodologies commonly used in the development and analysis of Thermal systems.
2. Problem Solving Skills: Graduates will demonstrate an ability to identify, formulate and solve thermal engineering problems.
3. **Design/ Development of solutions:** An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, health and safety, manufacturability, and sustainability.
4. **Multidisciplinary Approach:** An ability to function on multidisciplinary teams.
5. **Modern tool usage:** An ability to identify, formulate, and solve engineering problems using modern tools and techniques.
6. **Communication:** An ability to communicate effectively.
7. **The Engineer and Society:** The broad education necessary to understand the impact of mechanical engineering solutions in a local, global, economic, environmental, and societal context.
8. **Life-long learning:** A recognition of the need for, and an ability to engage in life-long learning.
9. **Investigations of complex problem:** Use of Applied research including design of experiments, analysis and interpretation of data, synthesis of the information to provide valid solutions with the knowledge of contemporary issues.
10. **Project Management:** An ability to apply engineering knowledge and management principles skills to manage engineering projects.
11. **Environment and Sustainability:** An ability to design sub-systems, systems, components and processes to fulfil demand of environmental sustainability.
12. **Ethics:** Apply engineering principles toward the professional values and ethics.

Program Specific Outcomes (PSOs): At the end of the program, student will be able

1. To **analyse the problems** and **create solution** by applying engineering knowledge with a multidisciplinary approach in the area of thermal engineering, manufacturing systems and product design.
2. To analyze, interpret and provide solutions to the real life mechanical engineering problems **using engineering software/tools.**
3. **To work effectively in a team** to address **complex issues** by engaging in **lifelong learning** and following **ethical and environmental** practices

COURSE STRUCTURE FOR M.TECH. MECHANICAL FIRST YEAR (Thermal Engineering)
w.e.f 2018-19

SEMESTER-I (Subjects)			M.TECH. Sem.-I (Thermal)										
Sr. No	Course Code	Course Name	Teaching Scheme					Exam Scheme					
			L	T	P	C	Hrs/wk	Theory			Practical		Total
								MS	ES	CE	LE	LE/Viva	Marks
1	16MA503T	Advance Numerical and Computing Techniques	3	1	0	4	4	25	50	25	-	-	100
2	16MA503P	Advance Numerical and Computing Techniques	-	-	2	1	2	-	-	-	25	25	50
3	16ME501T	Advanced Fluid Mechanics	3	0	0	3	3	25	50	25	-	-	100
4	16ME502T	Advanced Engineering Thermodynamics	3	0	0	3	3	25	50	25	-	-	100
5	16ME503P	Thermal Lab-I	0	0	4	2	4	-	-	-	25	25	50
6	16ME5XXT	Elective I	3	0	0	3	3	25	50	25	-	-	100
7	16ME5XXT	Elective II	3	0	0	3	3	25	50	25	-	-	100
		Total	**15**	**1**	**6**	**19**	**22**	**125**	**250**	**125**	**50**	**50**	**600**

MS = Mid Semester, ES = End Semester; CE = Continuous Evaluation
LW = Laboratory work; LE = Laboratory Exam

Elective I: (i) ME 510: Heating Ventilation and Air conditioning (ii) ME 511: Advanced Gas Dynamics
Elective II: (i) ME 512: Cryogenics (ii) ME 513: Renewable Energy Management

Course Code: 16MA503T					Course Name: Advance Numerical and Computing Techniques			
Teaching Scheme					**Examination Scheme**			
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Total**
3	1	--	4	4	**Continuous Evaluation**	**Mid Semester**	**End Semester**	100
					25	25	50	

Course Outcome (COs):

Students who successfully complete this course should be able to demonstrate understanding of :

CO1: Common numerical methods and how they are used to obtain approximate solutions to otherwise intractable mathematical problems.

CO2: Apply numerical methods to obtain approximate solutions to mathematical problems.

CO3: Derivation of numerical methods for various mathematical operations and tasks, such as interpolation, differentiation, integration, the solution of linear and nonlinear equations, and the solution of ordinary and partial differential equations using finite difference method.

CO4: Find the complex roots using Graffe's root squaring method

CO5: Analyze and evaluate the accuracy of common numerical methods.

UNIT-I **(12L, 4T)**

Concept of Error in Computation

Interpolation: Introduction of Finite differences, Operators, Newton Gregory Forward Interpolation Formula, Newton Gregory Backward Interpolation Formula, Gauss's Forward and Backward Interpolation Formula, Stirling's Central Difference Formula, Lagrange's Interpolation Formula for unevenly spaced data, Inverse Interpolation, Divided Differences, Properties of Divided Differences, Newton's Divided Difference Formula, Relation between Divided Differences and Ordinary Differences.

Splines, Cubic Splines, Formulae for Derivatives, Newton-Cotes's Quadrature Formula, Trapezoidal rule, Simpson's one-third rule, Simpson's Three-Eighth rule, Weddle's rule, Romberg's method, Double Integration.

UNIT-II **(09L, 3T)**

Concept of Rate of Convergence

Numerical solution of Algebraic & Transcendental Equations: Introduction, Descarte's Sign rule, Newton-Raphson method, it's applications, Solution of non linear simultaneous equations, Newton-Raphson method for multiple roots, Horner's method, Lin-Bairstow's method or Method for Complex Root, Graeffe's root squaring method, Comparison of various methods.

UNIT-III **(10L, 3T)**

Numerical Solution of Ordinary and Partial Differential Equations: Picard's method, Taylor's method, Euler's method, Runge – Kutta method, Modified Euler's method, Predictor Corrector methods: Adam's method, Milne's method. Difference Quotients, Graphical representation, Classification of PDE's of 2^{nd} order, Elliptic equations, Solutions of Laplace equation by Liebmann's, iteration method, Poisson's equation, Parabolic equation (One dimension heat equation),Bender-Schmidt method, Crank- Nicholson method.

UNIT-IV **(09, 3T)**

Curve Fitting: Principle of Least Squares, Fitting a Straight line and other Curves for a given set of data points .

Solution of Simultaneous Algebraic Equations: Direct methods, Iterative methods: Gauss-Jacobi's method, Gauss-Seidal method, Relaxation method.

The Finite Element Method: Introduction, Method of Approximation, The Rayleigh-Ritz Method, The Galerkin Method, Application to One dimensional and two dimensional problems.

Lecture: 40 Hrs
Tutorial: 13 Hrs
Approximate Total : 53 Hrs

Texts and References

1. Introductory Methods for Numerical Analysis by S.S. Sastry, Fourth edition, Prentice Hall of India (2009)
2. Numerical Methods in Engineering and Science with Programs in C & C++ by B.S. Grewal, Khanna Publisher (2010)
3. Numerical Methods for Scientific and Engineering Computation by M.K. Jain, S.R.K. Iyenger and R.K. Jain, 5th edition, New Age International (2007)
4. S.D. Conte & C. de Boor: Elementary Numerical Analysis - an algorithmic approach, Mc Graw Hill, 1980, 3rd Ed., New York.
5. Advanced Engineering Mathematics by R.K. Jain & S.R.K. Iyenger, 3rd edition, Narosa (2002).
6. Advanced Engineering Mathematics by E. Kreyszig, 9th edition John Wiley & Sons (2005)
7. Numerical Methods by E. Balaguruswamy
8. Numerical Methods for Mathematics, Science & Engineering by John H. Mathews
9. Applied Numerical Analysis by Curtis F Gerald & Patrick O. Wheatley
10. Numerical Methods for Engineers, Steven C. Chapra and Raymond P. Canale, Tata McGraw-Hill Publishing Company Limited.

Course Code: 16MA503P					Course Name: Advance Numerical and Computing Techniques Lab		
Teaching Scheme					**Examination Scheme**		
L	**T**	**P**	**C**	**Hrs/Week**	**Practical**		**Total**
-	-	2	1	2	**Continuous Evaluation**	**End Semester**	50
					25	25	

Course Outcomes (COs):

On completion of the course, students will be able to

CO1: Apply numerical methods for data analysis, optimization, linear algebra and ODEs.
CO2: Understand MATLAB skills in numerical methods, programmingand graphics
CO3: Apply mathematical methods through computation using MATLAB.

Programing List (MATLAB)

1. Numerical solution of Algebraic & Transcendental Equations
2. Numerical Solution of Ordinary and Partial Differential Equations
3. Solution of Simultaneous Algebraic Equations
4. Finite Element Method

Course Code: 16ME501T					**Course Name:** Advance Fluid Mechanics			
Teaching Scheme					**Examination Scheme**			
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Total**
3	0	--	3	3	**Continuous Evaluation**	**Mid Semester**	**End Semester**	100
					25	25	50	

Course outcomes (COs):

On completion of the course, students will be able to

CO1: Understand the governing phenomenon and governing equations of fluid flow problem.
CO2: Analyze and obtain exact/approximate solution for different types of fluid flow problem
CO3: Understand, analyze and solve the laminar and turbulent flow problems
CO4: Understand the potential flow theory and analyze the potential flow problems
CO5: Understand and analyze the vorticity dynamics of the fluid flow.
CO6: Understand, analyze and solve the compressible flow problems

UNIT I **08**

Introduction: Flow patterns, fluid forces, Solid Vs. Fluid, Physical interpretation of Viscosity, Control volume approach etc.

Derivation of Governing Partial Differential Equations: Derivation of Continuity, Momentum and Energy equation Fluxes in Navier-Stokes Equation, Non dimensional N-S Equation, Initial and Boundary conditions, Integral parameters.

UNIT II **10**

Exact solution of Navier –Stokes Equation: Introduction, flow of two immiscible fluid in plane channel, flow in a pipe, flow between two concentric cylinder, stokes first and second problem, flow over a flat plate with suction,

Vorticity Dynamics: Introduction, vortex lines and tubes, Role of viscosity in Rotational and Irrotational flow, Kelvin's circulation theorem, Vorticity transport equation, Interaction of Vortices

UNIT III **10**

Laminar Boundary Layers: Ideal and Boundary Layer Theory, Prandtl's Model of boundary layer flow, order of magnitude analysis, flow over flat plate, Blasius solution for flow over flat plate, Boundary layer with non zero pressure gradient, Momentum integral approach,Karman-pohalhausen method for flat plat and duct, Separation and its prevention.

Potential Flow Theory: Incompressible-Inviscid flow, Numerical solution of plane Inviscid flow, Complex variables ,simple potential flows like uniform flow, Irrotational vortex,source,sink,doublet, flow past a half body, cylinder and cylinder with circulation,

UNIT IV

Turbulent Flow: **06**

Concept of linearized stability of parallel viscous flow, transition to turbulent flow, Reynolds equation for turbulent flow, Reynolds stresses, Prandtl's mixing length theory, velocity profile, Turbulent flow in pipes, turbulent boundary layer on flat plate.

Compressible Flow: **05**

Introduction, one dimensional compressible gas flow, flow in nozzle, effect of viscous friction and heat transfer, shocks in supersonic flow, Normal and oblique shocks

Lecture: 36 Hrs
Tutorial: 00 Hrs
Approximate Total : 39 Hrs

Texts and References

1. Advanced Engineering Fluid Mechanics, Muralidhar & Biswas
2. Fluid Mechanics and its Applications, Gupta and Gupta, 1988.
3. Fluid Mechanics, Kundu & Cohen, 2002.
4. Boundary Layer Theory: Schlichting & Gersten, 2000.
5. A first course in Turbulence: Tennekes & Lumley, 1972.

Course Code: 16ME502T					Course Name: Advanced Engineering Thermodynamics			
Teaching Scheme					**Examination Scheme**			
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Total**
3	0	--	3	3	**Continuous Evaluation**	**Mid Semester**	**End Semester**	100
					25	25	50	

Course outcomes (COs):

On completion of the course, students will be able to

CO-1: Extend in-depth knowledge in application the laws of thermodynamics

CO-2: Clarify availability concept and analyze availability cycles

CO-3: Explain multi-component systems.

CO-4: Provide broad knowledge to analyze HVAC and combustion Systems

CO-5: Develop design and optimization procedures for thermodynamic systems

UNIT-I Property relationships for pure substances and Mixtures 12

Thermodynamic Relations: Some mathematical theorems, Maxwell's equations, Tds equations, Difference in heat capacities, ratio of heat capacities, energy equation, Joule-Thomson effect. Clausius- Clapeyron equation, Evaluation of thermodynamic properties from an equation of state. Helmholtz and Gibbs functions; Maxwell's relations; Enthalpy, entropy, internal energy, and specific heat relations; Clausius-Clapeyron's equation; Applications to ideal and real gases. Joule-Thomson coefficient.

Ideal Gas Mixtures: Dalton's law of additive pressures, Amagat's law of additive volumes, evaluation of , properties. Analysis of various processes.

Pscychrometry : Atmospheric air and Psychometric properties; Dry bulb temperature, wet bulb temperature, dew point temperature; partial pressures, specific and relative humidity and the relation between the two. Enthalpy and adiabatic saturation temperature. Construction and use of psychometric chart. Analysis of various processes; heating, cooling, dehumidifying and humidifying. Adiabatic mixing of stream of moist air. Summer and winter air-conditioning.

UNIT II Combustion Thermodynamics 05

Theoretical (Stoichiometric) air for combustion of fuels. Excess air, mass balance, Exhaust gas analysis, A/F ratio. Energy balance for a chemical reaction, enthalpy of formation, enthalpy and internal energy of combustion. Combustion efficiency. Dissociation and equilibrium, emissions.

UNIT III Thermodynamics Cycles 09

Gas Power Cycles

Air standard cycles; Carnot, Otto, Diesel, Dual and Stirling cycles, p-v and T -s diagrams, description, efficiencies and mean effective pressures. Comparison of Otto and Diesel cycles. Gas turbine (Brayton) cycle; description and analysis. Regenerative gas turbine cycle. Inter-cooling and reheating in gas turbine cycles.

Vapor Power Cycles

Carnot vapor power cycle, drawbacks as a reference cycle. Simple Rankine cycle; description, T-s diagram, analysis for performance. Comparison of Carnot and Rankine cycles. Effects of pressure and temperature on Rankine cycle performance. Actual vapour power cycles. Ideal and practical regenerative Rankine cycles, open and closed feed water heaters. Reheat Rankine cycle.

Refrigeration Cycles

Vapour compression refrigeration system; description, analysis, refrigerating effect. capacity, power required, units of refrigeration, COP Refrigerants and their desirable properties. Air cycle refrigeration; reversed Carnot cycle, reversed Brayton cycle Vapour absorption refrigeration system. Steam jet refrigeration

UNIT IV Compressible Flows and Steam Nozzles **07**

Compressible Flows: Velocity of pressure pulse in fluid, stagnation properties, one dimensional steady isentropic flow, critical properties-choking in isentropic flow, normal shocks, adiabatic flow with friction and without friction, numerical problems.

Steam nozzles: Flow of steam through nozzles, shape of nozzles, effect of friction, critical pressure ratio, supersaturated flow. .

UNIT V Reciprocating Compressors **05**

Operation of a single stage reciprocating compressors. Work input through p-v diagram and steady state steady flow analysis. Effect of clearance and volumetric efficiency. Adiabatic, isothermal and mechanical efficiencies. Multi-stage compressor, saving in work, optimum intermediate pressure, inter-cooling, minimum work for compression.

Lecture: 38 Hrs
Tutorial: 00 Hrs
Approximate Total : 38 Hrs

Texts and References

1. Thermodynamics: an Engineering Approach, Y.A.Cengal and M.A.Boles, McGraw Hill (Fifth edition).
2. A. Bejan, Advanced Engineering Thermodynamics, 3rd edition, John Wiley and sons, 2006.
3. M.J.Moran and H.N.Shapiro, Fundamentals of Engineering Thermodynamics, John Wiley and Sons.
4. T.D. Eastop and A. Mcconkey Applied Thermodynamics for Engineering Technologists (5th Edition), Prentice Hall.
5. P.K. Nag, Engineering Thermodynamics, McGraw-Hill Education, 2008

<table>
<tr><td colspan="9">Course Code: 16ME503P Course Name: Thermal Engineering -I</td></tr>
<tr><th colspan="5">Teaching Scheme</th><th colspan="4">Examination Scheme</th></tr>
<tr><th>L</th><th>T</th><th>P</th><th>C</th><th>Hrs/Week</th><th colspan="2">Practical</th><th colspan="2">Total</th></tr>
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Course Outcomes (COs):

On completion of the course, students will be able to

CO1: Analyze and **Solve** problems involving fundamental laws of heat transfer.
CO2: Evaluate natural and forced convection heat transfer coefficient for a variety of flow conditions using appropriate empirical or theoretical equations for heat transfer coefficients and validate the acquired results with experimental results.
CO3: Analyze and evaluate different parameters of wind Tunnel by simulation and parametric study.
CO4: Evaluate performance of heat exchanger for different flow directions.

List of Experiments

1. Performance test of an aerofoil
2. Numerical simulation of aerofoil performance test
3. Heat balance sheet of IC engine.
4. Conductive heat transfer experiment.
5. Software based numerical simulation of conductive heat transfer experiment
6. Software based performance analysis of power plants.

Course Code: 16ME510T					**Course Name: Elective-I:** Heating Ventilation and Air conditioning			
Teaching Scheme					**Examination Scheme**			
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Total**
3	0	--	3	3	**Continuous Evaluation**	**Mid Semester**	**End Semester**	100
					25	25	50	

Course outcomes (COs):

On completion of the course, students will be able to

CO1: Demonstrate knowledge of heating, ventilation, Refrigeration and air conditioning for optimum performance

CO2: Estimate the cooling load requirement and Design Air Conditioning system for residential and automobile applications

CO3: Develop understanding of the principles and practice of thermal comfort and Develop generalized psychometrics of moist air and apply to HVAC processes

CO4: Review fluid mechanics and engineering and develop techniques for the analysis of duct and piping systems and room air distribution systems and review associated turbo machines and control systems

UNIT I **08**

Introduction: Overview of Industry and Scope of HVAC, applications of HAVC, definitions and terminology.

Psychrometry: Applied Psychrometry, Psychometric processes using chart - Basic processes such as sensible heating/cooling, humidification/dehumidification and their combinations, steam and adiabatic humidification, adiabatic mixing, etc. - Bypass factor and Sensible heat ratio.

UNIT II **11**

Human Comfort: Heat transfer from body, convection, radiation, conduction, evaporation, clothing resistance, activity level - Concept of human comfort – Thermal response - comfort factors – Environmental indices - Indoor air quality

Cooing Load Estimation: External load – solar radiations, wall, roof and glass etc.; internal load – occupancy, lighting, equipments; Ventilation - air quantity; Load estimation methods - Equivalent Temperature Difference Method, Cooling Load Temperature Difference, and Radiance Method, RSHF, GSHF, ESHF, etc.

Heating load estimation: Vapour transfer in wall, vapour barrier, and load estimation basics.

UNIT III **12**

Air Distribution: Ducts, Types of ducts, Fundamentals of air flow in ducts, pressure drop calculations, design ducts by velocity reduction method, equal friction method and static regain method, duct materials and properties, insulating materials, methods of sizing and balancing.

Ventilation: Requirement of ventilation air, various sources of infiltration air, ventilation and infiltration as a part of cooling load, threshold limits of contaminants, estimation of ventilation rates, decay equation, air flow round buildings. Methods of Ventilation - Natural, wind effect, stack effect, combined effect - Mechanical, forced, exhaust, and combined - Displacement ventilation.

Ventilation System Design: Exhaust ducts, filters, blowers, hoods, chimney, etc.

UNIT IV **08**

Air conditioning systems: Classification, design of central and unitary systems, typical air conditioning systems such as automobile, air plane, ships, railway coach air-conditioning, warm air system, hot water systems, heat pump, clean rooms etc.

Lecture: 39 Hrs
Tutorial: 00 Hrs
Approximate Total : 39 Hrs

Texts and References

1. ASHRAE Handbook - Fundamentals, American Society of Heating, Refrigerating and Air - Conditioning Engineers Inc., Atlanta, USA, 2009.
2. HVAC Handbook, ISHRAE
3. Refrigeration Handbook, ISHRAE

4. Industrial Ventilation Application Handbook, ISHRAE
5. Air conditioning and ventilation of buildings, Croome, D.J. and Roberts, B.M., Pergamon.
6. Refrigeration and Air Conditioning, Stoecker, W.F., and Jones, J.W., 2nd Edition, Tata McGraw Hill, New Delhi 1982.
7. Refrigeration and Air Conditioning, Arora, C.P., Tata-McGraw- Hill, New Delhi, 2003.
8. Heating, Ventilating and Air Conditioning-Analysis and Design, McQuiston, Faye; Parker, Jerald; Spitler, Jeffrey, 5th ed. John Wiley & Sons, 2000.

Course Code: 16ME511T					Course Name: Elective-I: Advanced Gas Dynamics			
Teaching Scheme					**Examination Scheme**			
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Total**
3	0	--	3	3	**Continuous Evaluation**	**Mid Semester**	**End Semester**	100
					25	25	50	

Course outcomes (COs):

On completion of the course, students will be able to

CO1: Understand Fundamental Aspects of Gas Dynamics, Normal Shock Waves, Variable Area Flow, Flow with Heat addition and Two-Dimensional Compressible Flow

CO2: Analyze normal and oblique shock waves; and Prandtl Meyer flows.

CO3: Understand and apply mathematical treatment to various problems related to Generalized Quasi-One-Dimensional Flow, Two-Dimensional Compressible Flow, shock wave relations, and isentropic relations to reasonable correctness.

CO4: Analyze one and two dimensional isentropic compressible flows with effects of friction and heat transfer.

CO5: Apply principles of dimensional analysis and simulated for solving compressible fluid flow problems.

UNIT I **10**

Review of fundamentals: Types of flows, concepts of continuum and control volume, generalized continuity, momentum and energy equations, velocity of sound and its importance, physical difference between incompressible, subsonic and supersonic flows, three reference speeds, dimensionless velocity M*, concepts of static and stagnation parameters.

One dimensional isentropic flow: General features, working equations, choking in Isentropic flow, operation of nozzles and diffusers under varying pressure ratios, performance of real nozzles, applications of isentropic flow.

UNIT II **12**

Normal shocks: Introductory remarks, governing equations, Rankine–Hugonout, Prandtl's and other relations, weak shocks, thickness of shocks, normal shocks in ducts, performance of convergent-divergent nozzle with shocks, moving shock waves, shocks problems in one dimensional supersonics diffuser, supersonic pilot tube.

UNIT III **12**

Flow in constant area duct with friction: Governing equations, working formulas and tables, choking due to friction, performance of long ducts, isothermal flow in long ducts, flow in constant area duct with heating and cooling.

Generalized one dimensional flow: Working equations, general method of solution, example of combined friction and area change, example of combined friction and heat transfer.

UNIT IV **08**

Multidimensional flow: Equation of continuity, Navier stock equation, potential flow, Method of characteristics.

Dimensional analysis and similitude: Buckingham pai theorem, Van driest theorem, Dimensional analysis, model study, compressible flow of viscous fluids.

Rarefied gas dynamics: Knudsen number, sleep flow, transition and free molecular flow

Forces on submerged bodies: Forces exerted by flowing fluid on a stationary body, drag, lift for different objects like sphere, cylinder, development of lift on a circular cylinder, development of lift on aerofoil.

Lecture: 42 Hrs
Tutorial: 00 Hrs
Approximate Total : 42 Hrs

Texts and References

1. Fundamentals of Compressible Flow by S.M. Yahya, New Age
2. Gas Dynamics by Ali Campbell & Lenning
3. Gas Dynamics by Radha Krishnan , PHI

Course Code: 16ME512T					Course Name: Elective-II: Cryogenics			
Teaching Scheme					**Examination Scheme**			
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Total**
3	0	--	3	3	**Continuous Evaluation**	**Mid Semester**	**End Semester**	100
					25	25	50	

Course outcomes (COs):

On completion of the course, students will be able to

CO1: Demonstrate knowledge of heating, ventilation, Refrigeration and air conditioning for optimum performance

CO2: Estimate the cooling load requirement and Design Air Conditioning system for residential and automobile applications

CO3: Develop understanding of the principles and practice of thermal comfort and Develop generalized psychometrics of moist air and apply to HVAC processes

CO4: Review fluid mechanics and engineering and develop techniques for the analysis of duct and piping systems and room air distribution systems and review associated turbo machines and control systems

UNIT I **10**

Introduction to properties of engineering materials at cryogenic temperatures, mechanical properties, thermal properties, electric & magnetic properties, super conducting materials, thermo electric materials, composite materials, properties of cryogenic fluids, super fluidity of He3 & He 4.

Cryogenic insulation – expanded foams, gas filled & fibrous insulation, vacuum insulation, evacuated powder & fibrous insulation, opacified powder insulation, multilayer insulation, comparison of performance of various insulations .

UNIT II **11**

Applications of cryogenic systems: Super conductive devices such as bearings, motors, cryotrons, magnets, D.C. transformers, tunnel diodes, space technology, space simulation, cryogenics in biology and medicine, food preservation and industrial applications, nuclear propulsions , chemical propulsions.

Cryogenic Refrigeration System: Ideal isothermal and reversible isobaric source refrigeration cycles, Joule Thomson system, cascade or pre-cooled joule–Thomson refrigeration systems, expansion engine and cold gas refrigeration systems,

UNIT III **11**

Advanced Cry coolers: Philips refrigerators, Importance of regenerator effectiveness for the Philips Refrigerators, Gifford single volume refrigerator, Gifford double volume refrigerators analysis, COP, FOM, regenerators, pulse tube refrigerators, various types of pulse tube refrigerator.

Refrigerators using solids as working media: Magnetic cooling, magnetic refrigeration systems, thermal; valves, nuclear demagnetization.

UNIT IV **10**

Gas liquefaction systems: Introduction, thermodynamically ideal systems, Joule Thomson effect, liquefaction systems such as Linde Hampton, precooled Linde Hampson, Linde dual pressure, cascade, claude, kapitza, heyland systems using expanders, comparison of liquefaction systems.

Lecture: 42 Hrs
Tutorial: 00 Hrs
Approximate Total : 42 Hrs

Texts and References

1. Cryogenic process engineering, Thomas M Flynn, Informa Health Care, 2004

2. Miniature refrigerators for cryogenic sensors and cold electronics, Graham Walker,
3. Clarendon Press, 1989
4. Cryogenic technology & applications, A R Jha, Butterworth-Heinemann, 2006,
5. Cryocooler, Fundamentals Part I &II, Graham Walker, Plenum Press, New York
6. Cryogenic Regenerative Heat Exchangers, R.A. Ackermann, Springer, 1997
7. Cryogenic systems, R F Barron, Oxford University Press,
8. Cryogenic heat transfer, R F Barron, Taylor & Francis Group
9. Cryogenics: A Text Book, S. S. Thipse, Alpha Science Intl Ltd
10. Fundamentals Of Cryogenic Engineering, Mamata Mukhopadhyay, PHI
11. Fundamentals of Vacuum Engineering, Pipkov, Mir Publication.

Course Code: 16ME513T					**Course Name: Elective-II:** Renewable Energy & Energy Management			
Teaching Scheme					**Examination Scheme**			
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Total**
3	0	--	3	3	**Continuous Evaluation**	**Mid Semester**	**End Semester**	100
					25	25	50	

Course outcomes (COs):

On completion of the course, students will be able to

CO1: Ability to designs small scale solar photovoltaic and wind energy systems.
CO2: Perform energy auditing of thermal systems and design of energy efficient systems, use of non-conventional energy generation techniques to improve system performance.
CO3: Analyze thermal systems, apply principles of energy management and Apply heat recovery systems to improve system performance.
CO4: Design and Analyze heat exchanger networks for optimal performance.

UNIT I **12**

Solar energy: Devices for thermal collection, solar energy applications
Wind energy: analysis of wind speeds, different types of wind turbines, Wind date, factors for site selection, performance characteristics
Bio Energy: Biomass gasifies, types, design and construction of biogas plants, scope and future.
Tidal, wave and ocean thermal energy conversion plants, geothermal plants

UNIT II **11**

Energy Management: Its importance, Steam Systems: Boiler efficiency testing, excess air control, Steam distribution, condensate recovery, flash steam utilization, Thermal Insulation Energy conservation in Pumps, Fans, Compressed Air Systems, Refrigeration & Air conditioning systems

UNIT III **09**

Waste heat recovery: Recuperates, heat pipes, heat pumps, Cogeneration - concept, options (steam/gas turbines/diesel engine based), selection criteria, control strategy

UNIT IV **10**

Heat exchanger networking: concept of pinch, target setting, problem table approach, composite curves.
Demand side management, financing energy conservation

Lecture: 42 Hrs
Tutorial: 00 Hrs
Approximate Total : 42 Hrs

Texts and References

1. Solar Energy by S P Sukhatme and J K Nayak
2. Solar Engineering of Thermal Processes by Duffie and Backman
3. Energy Management and Conservation Frank Kreith and D Yogi Goswami Handbook CRC press
4. TERI hand book on Energy Conservation
5.Industrial Energy Conservation Manuals, MIT Press
6. Heat Exchanger Network Synthesis- Process Optimisation by Energy and Resource Analysis by Uday V Shenoy, Gulf Publ. Company

COURSE STRUCTURE FOR M.TECH. MECHANICAL FIRST YEAR (Thermal Engineering) w.e.f 2018-19

SEMESTER II (Subjects)			**M.TECH. Sem. – II (Thermal)**										
			Teaching Scheme					**Exam Scheme**					
Sr. No	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**	**Hrs/wk**	**Theory**			**Practical**		**Total**
								MS	**ES**	**CE**	**LW**	**LE/Viva**	**Marks**
1	16ME504T	Experimental Methods	3	0	0	3	3	25	50	25	--	--	100
2	16ME505T	Advance Heat Transfer	3	0	0	3	3	25	50	25	--	--	100
3	16ME506T	Computational Fluid Dynamics	3	1	0	4	4	25	50	25	--	--	100
4	16ME 507P	Thermal Lab-II	0	0	4	2	4				25	25	50
5	16ME5XXT	Elective III	3	0	0	3	3	25	50	25	--	--	100
6	16ME5XXT	Elective IV	3	0	0	3	3	25	50	25	--	--	100
7		Successful Research and Development Program	2	0	0	-	2	-	-	-	-	-	NP/PP
		Total	**17**	**1**	**4**	**18**	**22**	**125**	**250**	**125**	**25**	**25**	**550**

MS = Mid Semester, ES = End Semester; CE = Continuous Assessment
LW = Laboratory work; LE = Laboratory Exam

Elective III: (i) 16ME514T: Design and Optimization of Thermal Systems (ii) 16ME515T: Advanced Convective Heat Transfer
Elective IV: (i) 16ME516T: Solar Thermal Systems (ii) 16ME517T: Turbo machinery (iii) 16ME518T: Finite Element Methods

Course Code: 16ME504T					**Course Name:** Experimental Methods			
Teaching Scheme					**Examination Scheme**			
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Total**
3	0	--	3	3	**Continuous Evaluation**	**Mid Semester**	**End Semester**	100
					25	25	50	

Course outcomes (COs):

On completion of the course, students will be able to

CO1: Analyze the need, design and perform a set of experiments.

CO2: Analyze of experimental results uncertainty of experimental results using various uncertainty analysis techniques.

CO3: Apply multivariate analysis to study effects of multiple variable

UNIT I **08**

Strategy of experimentations: Applications of experiment methods, basic principles, design guidelines, statistical design and problems. Experimental design; statistical analysis of data; computerized data acquisition and reduction; experiments on signature analysis, fluid flow, heat transfer, material properties, and vibrations; individual experimental design projects

UNIT II **09**

Comparative Experiments: Statistical concepts**,** probability, variations, correlations, transformation techniques, central limits, significance, confidence limits, distribution test, analysis of variance, goodness of fit, non parametric methods.

UNIT III **08**

Analysis of sequence of data: Measurements in sequences, interpolation procedures, Markov chains, series of events, runs test, calibration, regression analysis, splines, segmenting sequences, autocorrelation, semi variograms, spectral analysis.

UNIT IV **05**

Spatial analysis: systematic patter search, distribution of points, distributions of lines, analysis of directional data, spherical distributions, fractal analysis, kriging.

UNIT V **12**

Analysis of multivariate data: Multiple regression, discriminant function, cluster analysis, factor analysis, principle component analysis, mode factor analysis, principle coordinate analysis, correspondence analysis, multidimensional scaling, canonical correlation.

Concept to Testing: Research question, hypothesis, defining, gathering, analyzing, concluding, variable, values, observation, scales of measurements, error analysis, hypothesis testing

Lecture: 42 Hrs
Tutorial: 00 Hrs
Approximate Total : 42 Hrs

Texts and References

1. D.C. Montgomery, Design and Analysis of Experiments, John Wiley, New York, 2001.
2. R. S. Figliola and D. E. Beasley, Theory and Design for Mechanical Measurements, John
3. Wiley Publication.

4. T.G. Beckwith, R. D. Marangoni and J. H. Lienhard N.L., Mechanical Measurements, Pearson Education, 2003.
5. E.O. Doeblin, Measurement Systems, McGraw-Hill, New York, 1986.
6. R.J. Goldstein (Editor), Fluid Mechanics Measurements, Hemisphere Publishing Corporation, New York, 1983; second edition, 1996.
7. C. Tropea, J. Foss and A. Yarin Springer Handbook of Experimental Fluid Mechanics, 2007.
8. J. P. Holman, Experimental Methods for Engineers, Mc Graw Hill, 2007.
9. R.S. Figliola, and D.E. Beasley, Theory and Design for Mechanical Measurements - 2nd Edition, Wiley, 1995

Course Code: 16ME505T					**Course Name:** Advanced Heat Transfer			
Teaching Scheme					**Examination Scheme**			
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Total**
3	0	--	3	3	**Continuous Evaluation**	**Mid Semester**	**End Semester**	100
					25	25	50	

Course outcomes (COs):

On completion of the course, students will be able to

CO1: Apply scientific and engineering principles to analyze and design thermo-fluid aspects of engineering systems.

CO2: Apply appropriate analytical and computational tools to investigate heat and mass transport phenomena.

CO3: Implement heat transfer problems using computational tools.

CO4: Design codes for solving heat transfer problems and interpret solutions to heat transfer problems

UNIT I **13**

Conduction: Conservation equations; 1-D, 2-D, and 3-D steady conduction; 1-D unsteady conduction; Solution methods - analytical and numerical; extended surfaces

UNIT II **16**

Convection: conservation equations and boundary conditions; One-dimensional solutions; External and internal flow convection; heat transfer in laminar developed and developing duct flows; Laminar boundary layers: Similarity and integral solutions; Turbulence fundamentals and modeling; Heat transfer in turbulent boundary layers and turbulent duct flows; Fundamentals of boiling and condensation

UNIT III **10**

Radiation: Fundamentals; radiative properties of surfaces; Radiant exchange between surfaces; radiative heat transfer in participating media.

Lecture: 39 Hrs
Tutorial: 00 Hrs
Approximate Total : 39 Hrs

Texts and References

1. M N Ozisik, *Heat Conduction*, 2nd ed, John Wiley & Sons, 1993
2. F P Incropera and D P Dewitt, *Introduction to Heat Transfer*, 3rd ed, John Wiley & Sons, 1996
3. V S Arpaci, *Conduction Heat Transfer*, Addison-Wesley, Reading, MA, 1966
4. M F Modest, *Radiative Heat Transfer*, McGraw-Hill, 1993
5. R Siegel and J R Howell, *Thermal Radiation Heat Transfer*, 3rd ed, Taylor & Francis, 1992
6. W. M. Kays and E. M. Crawford, *Convective Heat and Mass Transfer*, Mc Graw Hill,1993.
7. Louis C Burmeister, *Convective Heat Transfer*, John Wiley and Sons, 1993.
8. Adrian Bejan, *Convective Heat Transfer*, John Wiley and Sons, 1995.

Course Code: 16ME506T					Course Name: Computational Fluid Dynamics			
Teaching Scheme					Examination Scheme			
L	T	P	C	Hrs/Week	Theory			Total
3	1	--	4	4	Continuous Evaluation	Mid Semester	End Semester	100
					25	25	50	

Course outcomes (COs):

On completion of the course, students will be able to

CO1: Formulate governing partial differential equations of fluid flow and heat transfer problems.
CO2: Able to critically analyze different mathematical models and computational methods for flow simulations.
CO3: Apply various discretization methods to solve fluid flow and heat transfer problems,
CO4: Use CFD software to model relevant engineering flow problems. Analyze the CFD results. Compare with available data, and discuss the findings.
CO5: Demonstrate the ability to use modern CFD software tools to build flow geometries, generate an adequate mesh for an accurate solution, select appropriate solvers to obtain a flow solution, and visualize the resulting flow field

UNIT I **09**

Introduction to Computational Fluid Dynamics and Principles of Conservation: Computational Fluid Dynamics: What, When, and Why?, CFD Applications, Numerical vs Analytical vs Experimental, Modeling vs Experimentation, Fundamental principles of conservation Mass, momentum and energy equations; Conservative forms of the equations and general description, physical boundary **conditions.**
Numerical Methods: Classification into various types of equations – parabolic, elliptic, hyperbolic and mixed type; Boundary and initial conditions; Overview of numerical methods.

UNIT II **10**

Discretization: Finite Difference Method - explicit, implicit, stability requirement, polynomial fitting, approximation of boundary conditions, applications to heat conduction and convection; Finite Element Method: Variational principle and weighted residual, Rayleigh-Ritz, Galerkin and Least square methods, 1-D and 2-D elements, applications to fluid flow and heat transfer problems; Finite Volume Method **–** finite volume discretization, approximation of surface and volume integrals, interpolation methods - central, upwind and hybrid formulations and comparison.

UNIT III **10**

Methods of Solution: Solution of finite difference equations, iterative methods, matrix inversion methods, ADI technique, SIMPLE algorithm, operator splitting, fast Fourier transform, applications.
Numerical Grid Generation: Grid generation techniques, transformation and mapping, structured and unstructured grid generation, Application of grid generation techniques.

UNIT IV **10**

Introduction and Application of ANSYS Fluent: Geometric modeling-ANSYS Workbench/CFX, mesh generation, boundary and initial conditions, computational approach, analysis.
Case Study: Numerical simulation of steady and un-steady process of fluid transport with and without heat transfer using ANSYS software – use ANSYS Workbench for geometrical modeling and turbulence models (i.e., RNG k-ε model, Standard k-ε model) for comparative analysis.

Lecture: 39 Hrs
Tutorial: 00 Hrs
Approximate Total : 39 Hrs

Texts and References

1. Computational Fluid Mechanics and Heat Transfer, Richard Pletcher, John Tannehill and Dale Anderson, CRC Press, 2012.
2. An introduction to computational fluid dynamics: The finite volume method, H.K. Versteeg and W. Malalasekera, Pearson Education, 2007.
3. Numerical Computation of Internal and External Flows, Charles Hirsch, Vol.2 , John Wiley & Sons, 1990.
4. Computational Methods for Fluid Dynamics, J. H. Fergiger, M. Peric, Springer, 2002.
5. Computational Fluid Dynamics, T. J. Chung, Cambridge University Press, 2010.
6. Computational Techniques for Fluid Dynamics Vol. 1, C. A. J. Fletcher, Springer, 1991.
7. Computational Techniques for Fluid Dynamics Vol. 2, C. A. J. Fletcher, Springer, 1991.
8. Computational Fluid Dynamics, J. D. Anderson Jr., McGraw-Hill International Edition, 1995.
9. Computational Fluid Mechanics and Heat Transfer, John C. Tannehill, Dale A. Anderson and Richard H. Pletcher, Taylor &Francis.
10. Computational Fluid Dynamics, John D. Anderson Jr., McGraw Hill Book Company.
11. Computational Fluid Dynamics: Principles and Applications, J. Blazek, Elsevier.
12. Computational Methods for Fluid Dynamics, Ferziger, J. H. and Peric, M., Third Edition, Springer-Verlag, Berlin, 2003.
13. Introduction to Computational Fluid Dynamics: The Finite Volume Method, Versteeg, H. K. and Malalasekara, W., Second Edition (Indian Reprint) Pearson Education, 2008.

Course Code: 16ME507P				**Course Name:** Thermal Engineering –II Lab.			
Teaching Scheme					**Examination Scheme**		
L	**T**	**P**	**C**	**Hrs/Week**	**Practical**		**Total**
					Continuous Evaluation	**End Semester**	
-	-	4	2	4	25	25	50

Course Outcomes (COs):

On completion of the course, students will be able to

CO1: Analyze and **Solve** problems involving fundamental laws of heat transfer in steam condensation and effect of fins.

CO2: Evaluate natural and forced convection heat transfer coefficient for a variety of flow conditions using appropriate empirical or theoretical equations for heat transfer coefficients and validate the acquired results with experimental results.

CO3: Analyze and evaluate performance of heat exchangers using LMTD and NTU methods.

CO4: Evaluate radiative heat exchange between two or more surfaces of different geometries.

List of Experiments

1. Convective heat transfer experiment and modeling.
2. Radiative heat transfer experiment and modeling.
3. Compact heat exchanger performance test.
4. Solar thermal experiment.
5. Developing and fully developed flow simulation.
6. Flow visualization and velocity field determination using PIV.

<table>
<tr><td colspan="5">Course Code: 16ME515T</td><td colspan="4">Course Name: Elective-III: Advanced Convective Heat Transfer</td></tr>
<tr><td colspan="5">Teaching Scheme</td><td colspan="4">Examination Scheme</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td>C</td><td>Hrs/Week</td><td colspan="3">Theory</td><td>Total</td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">0</td><td rowspan="2">--</td><td rowspan="2">3</td><td rowspan="2">3</td><td>Continuous Evaluation</td><td>Mid Semester</td><td>End Semester</td><td rowspan="2">100</td></tr>
<tr><td>25</td><td>25</td><td>50</td></tr>
</table>

Course outcomes (COs):

On completion of the course, students will be able to

CO1: Apply conservation laws for laminar flow through boundary layer.
CO2: Solve variety of convection heat transfer problems for internal flow, external flows.
CO3: Analyze effects of temperature of fluid on its properties and heat transfer rates
CO4: Student will be equipped with the analytical and model synthesis skills needed to apply the fundamentals to a wide variety of complex engineering problems.

UNIT I **09**

Laminar Boundary Layer:

Introduction, Conservation Principles, Fluid Stresses and Flux Laws; Laminar Boundary Layer, Integral Equations for the Boundary Layer; Laminar Internal Flows: Momentum Transfer & heat transfer; Laminar External Boundary Layers: Momentum Transfer & heat transfer

UNIT II **10**

Turbulent Boundary Layer:

Differential Equations for the Turbulent Boundary Layer; Turbulent External Boundary Layers: Momentum Transfer & heat transfer; Turbulent Internal Flows: Momentum Transfer & heat transfer

UNIT III **10**

Influence of Temperature-Dependent Fluid Properties ; Convective Heat Transfer at High Velocities ; Convective Heat Transfer with Body Forces

Lecture: 39 Hrs
Tutorial: 00 Hrs
Approximate Total : 39 Hrs

Texts and References

1. William M. Kays, M. Crawford and B. Weigand, *Convective heat and mass transfer*, 4th Ed., McGraw Hill
2. Louis C. Burmeister, *Convective Heat Transfer*, John Wiley and Sons, 1993.
3. Adrian Bejan, *Convective Heat Transfer*, John Wiley and Sons, 1995.

Course Code: 16ME516T					Course Name: Elective-IV: Solar Thermal Systems			
Teaching Scheme					Examination Scheme			
L	T	P	C	Hrs/Week	Theory			Total
3	0	--	3	3	Continuous Evaluation	Mid Semester	End Semester	100
					25	25	50	

Course outcomes (COs):

On completion of the course, students will be able to

CO-1: Understand the terms of earth-sun geometry and **analyze** the availability of solar radiation at various locations.

CO-2: Study and **classify** various solar thermal heat capturing configurations

CO-3: Find the ways to use solar energy for various applications like heating, cooling, drying, water distillation and electricity and **evaluate** their performance.

CO-4: Understand the concepts of solar thermal system design and its economic analysis.

UNITI: Basics of Solar Energy and Low Temperature Solar Thermal Systems 10

Solar geometry and solar resource assessment, Active and passive low temperature solar thermal systems. Solar water heaters with natural and forced circulations. Components: Flat plate and Evacuated tube collector, energy storage, auxiliaries. Solar water heater performance, efficiency.

UNIT II Space drying, Cooling and Thermal storage 08

Solar drying, technology for drying, Thermal energy storage: sensible and latent heat storage, Solar vapor absorption and space cooling.

UNIT III Process Heating Generation 07

Solar Cooking: Methods and technology, Solar distillation: methods and technology, Solar systems for process heat production.

UNIT IV Solar Thermal Electric Power Plants 07

Types of solar thermal electric power plants based on parabolic trough, solar tower, parabolic dish and Linear Fresnel lenses.

UNIT V Solar Thermal System Design and Economics 07

Fundamentals of design calculations and analysis of solar thermal systems. Solar plant installation, economics.

Lecture: 39 Hrs
Tutorial: 00 Hrs
Approximate Total : 39 Hrs

Texts and References

1. Kalogirou S. A. Solar Energy Engineering: Process and systems, Academy Press, 2009
2. Duffie J. A, Beckman W. A., Solar Engineering of Thermal Processes, Wiley, 3rd ed, 2006
3. Sukhatme S. P., Nayak, J. K., Solar Energy-Principles of Thermal Collection and Storage, Tata McGraw Hill, 3rd ed, 2008
4. Dr. Felix A. Peuser & et al, Solar thermal systems- successful planning and construction, Solarpraxis AG, 2002
5. German Solar Energy Society, Planning and Installing Solar Thermal Systems- a guide for installers, architects and engineers, 2nd ed, 2010.

<table>
<tr><td colspan="5">Course Code: 16ME517T</td><td colspan="4">Course Name: Elective-IV: Turbo Machinery</td></tr>
<tr><th colspan="5">Teaching Scheme</th><th colspan="4">Examination Scheme</th></tr>
<tr><th rowspan="2">L</th><th rowspan="2">T</th><th rowspan="2">P</th><th rowspan="2">C</th><th rowspan="2">Hrs/Week</th><th colspan="3">Theory</th><th rowspan="2">Total</th></tr>
<tr><th>Continuous Evaluation</th><th>Mid Semester</th><th>End Semester</th></tr>
<tr><td>3</td><td>0</td><td>--</td><td>3</td><td>3</td><td>25</td><td>25</td><td>50</td><td>100</td></tr>
</table>

Course outcomes (COs):

On completion of the course, students will be able to

CO1: Apply the Euler's equation for turbomachinery to analyze energy transfer in turbomachines
CO2: Analyze the flow through cascade and estimate losses
CO3: Analyze the performance of turbo machinery
CO4: Design of turbomachines and to use them in engineering applications

UNITI: **09**

Introduction: Turbomachines; parts of a Turbomachines; Comparison with positive displacement machine; Classification: Application of First and Second Laws to Turbomachines, Efficiencies. Dimensionless parameters and their physical significance; Effect of Reynolds number; Specific speed; Illustrative examples on dimensional analysis and model studies.

Principles of turbo machinery: Transfer of energy to fluids, Performance characteristics, fan laws, selection of centrifugal, axial, mixed flow, Axial flow machines.

UNIT II **10**

Flow through Cascades: Two-dimensional Flow, Cascade of Blades, Cascade Tunnel, Axial Turbine Cascades, Axial Compressor Cascades. Analysis of cascade forces; Energy losses: Lift and Drag; Circulation and lift; efficiency of compressor cascade; performance of two dimensional cascades. The cascade wind tunnel. Compressor cascade performance; Turbine cascade performance; compressor cascade correlations. Fluid deviation; off design performance; Much number effects. Turbine cascade co-relation (Ainley); Optimum space chord ratio of turbine blades (Zweifel).

UNIT III **10**

Analysis of axial flow Machines: Axial flow fans and compressors: Rotor design airfoil theory, vortex theory, cascade effects, degree of reaction, blade twist, stage design, surge, choking and stall, stator and casing, mixed flow impellers. Design considerations for supersonic flow

UNIT IV **10**

Design and applications of blowers and Fans: Special design and applications of blower: induced and forced draft fans for air-conditioning plants, cooling towers, ventilation systems, booster systems.

Testing and control of Blowers and Fans: Performance testing, noise control, Speed control, throttling control at discharge and inlet.

Lecture: 39 Hrs
Tutorial: 00 Hrs
Approximate Total : 39 Hrs

Texts and References

1. Turbines, Compressors and Fans, S.M. Yahya, Tata McGraw Hill, 2007.
2. Fluid Mechanics, Thermodynamics of turbomachinery, Dixon, Pergamon Press, 1984.
3. Handbook of Turbomachinery, Edited by Earl Logan Jr, Ramendra Roy; Second Edition , Marcel Dekker, Inc, New York.
4. Principles of Turbo machines, D.G. Stephard, Macmillan Co., 1984.
5. Turbomachinery Design and Theory, Rama S.R.Gorla, Aijaz Khan, Marcel Dekker, Inc, New York
6. Fluid Dynamics and heat Transfer of Turbomachinery, Budugur Lakshminarayana, John Wiley and Sons, Inc.

COURSE STRUCTURE FOR M.TECH. MECHANICAL SECOND YEAR (Thermal Engineering)
w.e.f 2018-19

SEMESTER III (Subjects)			M. Tech. Second Year (Thermal Engineering)										
Sr. No	Course Code	Course Name	Teaching Scheme					Exam Scheme					
			L	T	P	C	Hrs/wk	Theory			Practical		Total
								MS	ES	CE	LW	LE/Viva	Marks
1	MT611	Seminar				5		40	60	--			100
2	ME602	Project				14		40	60	--			100
3	ME604	Industrial Training											PP/NP
Total						**19**		**80**	**120**				**200**

MS = Mid Semester, ES = End Semester; CE = Continuous Evaluation

LW = Laboratory work; LE = Laboratory Exam

COURSE STRUCTURE FOR M.TECH. MECHANICAL SECOND YEAR (Thermal Engineering)
w.e.f 2016-17

SEMESTER IV (Subjects)			M. Tech. Second Year (Thermal Engineering)										
Sr. No	Course Code	Course Name	Teaching Scheme					Exam Scheme					
			L	T	P	C	Hrs/wk	Theory			Practical		Total
								MS	ES	IA	LW	LE/Viva	Marks
1	MT 621	Seminar				5		40	60	--			100
2	MT622	Project & Dissertation				24		40	60	--			100
		Total				**29**		80	120				200

MS = Mid Semester, ES = End Semester; IA = Internal assessment (like quiz, assignments etc)

LW = Laboratory work; LE = Laboratory Exam