Curriculum

M. Tech. Mechanical (Thermal Engineering) Program

School of Technology

Pandit Deendayal Energy University

Course Structure of M. Tech. Mechanical (Thermal Engineering)
Approved in 2020-21 and w.e.f. Admission Batch: 2020

Program 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

Sem I, Sem II, Sem III, Sem IV

COURSE STRUCTURE FOR M.TECH. MECHANICAL FIRST YEAR Sem I (Thermal Engineering)
w.e.f 2020-21

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	20MA503T	Advanced Numerical Techniques & Computer Programming	3	1	0	4	4	25	50	25	-	-	100
2	20MA503P	Advanced Numerical Techniques & Computer Programming - Lab.	-	-	2	1	2	-	-	-	25	25	50
3	20MET501T	Advanced Fluid Mechanics	3	0	0	3	3	25	50	25	-	-	100
4	20MET502T	Advanced Engineering Thermodynamics	3	0	0	3	3	25	50	25	-	-	100
5	20MET503P	Thermal Lab-I	0	0	4	2	4	-	-	-	25	25	50
6		Elective I	3	0	0	3	3	25	50	25	-	-	100
7		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

(iii) Introduction to Aircraft Flight and Aerodynamics

Elective II: (i) ME 512: Cryogenic Systems (ii) ME 513: Energy Management

20MA503T					ADVANCED NUMERICAL TECHNIQUES AND COMPUTER PROGRAMMING					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	2	5	6	25	50	25	50	50	100

COURSE OBJECTIVES

- To understand and acquaint the concept of various numerical methods.
- To develop numerical skills in solving problem of engineering interest.
- To enrich the concept of finite element techniques.
- To extract the roots of a polynomial equation.

UNIT 1 EIGEN VALUES EIGEN VECTORS AND INTERPOLATION **10 Hrs.**

Eigen values and eigen vectors: Numerical evaluation of largest as well as smallest (numerically) Eigen values and corresponding Eigen vectors.

Interpolation: Introduction, Newton Gregory Forward Interpolation Formula, Newton Gregory Backward Interpolation Formula, Central difference interpolation formula, Lagrange's Interpolation Formula for unevenly spaced Formula, Error in interpolation, Newton's Divided Difference Formula, cubic spline interpolation, surface interpolation.

UNIT 2 NUMERICAL SOLUTION NON-LINEAR EQUATIONS AND POLYNOMIAL **8 Hrs.**

Introduction, Solution of nonlinear simultaneous equations, Descarte's Sign rule, Horner's method, Lin-Bairstow's method, Graeffe's root squaring method, Muller's method, Comparison of various methods.

UNIT 3 NUMERICAL SOLUTION OF ODEs AND PDEs **14 Hrs.**

Taylor's method, Euler's method, Runge-Kutta methods of various order, Modified Euler's method, Predictor corrector method: Adam's method, Milne's method. Solution of Boundary value problems using finite differences. Finite difference approximation of partial derivatives, Classification of 2nd order PDEs, different type of boundary conditions, solutions of Elliptic, parabolic and hyperbolic equations of one and two dimensions, Crank- Nicholson method, ADI method.

UNIT 4 FINITE ELEMENT METHOD **8 Hrs.**

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

40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – To apply a suitable numerical technique to extract approximate solution to the problem whose solution cannot be obtained by routine methods.

CO2 – To estimate the errors in various numerical methods.

CO3 – To analyze/interpret the achieved numerical solution of problems by reproducing it in graphical or tabular form.

CO4 – To approximate the data generated by performing an experiment or by an empirical formula with a polynomial on which operations like division, differentiation and integration can be done smoothly.

CO5 – To evaluate a sufficiently accurate solution of various physical models of science as well as engineering interest whose governing equations can be approximated by nonlinear ODEs or PDEs or system of ODEs or PDEs.

CO6 – To design/ create an appropriate numerical algorithm for various problems of science and engineering.

TEXT/REFERENCE BOOKS

1. B.S. Grewal, Numerical Methods in Engineering and Science with Programs in C & C++, Khanna Publishers (2010).
2. S.S. Sastry, Introductory Methods for Numerical Analysis,4th Ed., Prentice Hall of India (2009).
3. M.K. Jain, S.R.K. Iyenger and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 5thEd., New Age International (2007).
4. C F Gerald and P O Wheatley, Applied Numerical analysis, Pearson education, 7th edition, 2003.
5. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley publication, 9th edition. 2005
6. R.K. Jain & S.R.K. Iyenger, Advanced Engineering Mathematics, 3rd Ed., Narosa (2002).
7. S C Chapra, Raymond P. Canale, Numerical Methods for Engineers, Tata McGraw Hill Pub. Co. Ltd.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs.**

Part A: 4 questions 6 marks each 24 Marks (40 min)

Part B: 4 questions 10 marks each 40 Marks (60 min)

Part C: 3 questions 12 marks each 36 Marks (40 min)

20MET501T					Advanced Fluid Mechanics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To obtain the governing equation of various types of fluid flow with tensor algebra.
- To attain the exact solution for Navier-Stokes equation for several complex fluid flow problems.
- To understand the basics of boundary layer theory, flow instability and turbulent flows.

UNIT 1 Review of the Fundamentals with tensor notations **10 Hr**

Concept of continuum and definition of a fluid. Body and surface forces, stress tensor, principle of local stress equilibrium. Scalar and vector fields, Eulerian and Lagrangian description of flow. Motion of fluid element translation, rotation and deformation; vorticity and strain-rate tensors. Continuity equation, Cauchy's equations of motion, Transport theorems. Constitutive equations-Stokes law of viscosity. Derivation of Navier-Stokes equations for compressible flow. Constitutive equations-Stokes law of viscosity; Control Volume Analysis - The Reynolds' Transport Theorem (RTT); Concept of Stress; Stress as a Tensor; The Traction Vector; The Cauchy Momentum Equation; Constitutive Equation and the Navier-Stokes Equations; Motion of Inviscid Fluids - Euler's Equation of motion; Bernoulli's Equation (Steady and Unsteady).

UNIT 2 Exact solution to Navier Stokes equation **11 Hr**

Exact Solutions to the Navier-Stokes Equations: plane Poiseuille flow and Couette flow, Hagen-Poiseuille flow, flow between two concentric rotating cylinders, Stokes first and second problems, Hiemenz stagnation-point flow, flow near a rotating disk, flow in convergent-divergent channels. Slow viscous flow: Stokes and Oseens approximation, theory of hydrodynamic lubrication. Boundary layer: derivation, exact solutions, Blasius, Falkner Skan, series solution and numerical solutions. Approximate methods. Momentum integral method; Stokes' first Problem; Oscillating flows - Stokes' Second Problem; Transient Pressure Driven Flow in a channel; Oscillating Flow in a channel; Transient Pressure Driven Flow in a channel; Oscillating Flow in a channel; Navier-Stokes equations in terms of Stream Functions. MATLAB based numerical solution to Oscillating flows – Stoke's first problem and Stokes' Second Problem.

UNIT 3 Laminar boundary layer theory **12 Hr**

Boundary layer: derivation, exact solutions, Blasius, Falkner Skan, series solution and numerical solutions. Approximate methods. Momentum integral method. Two dimensional and axisymmetric jets. 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 plate and duct, Separation and its prevention.

UNIT 4 Introduction to flow Instabilities and turbulent flows **12 Hr**

Introduction to Instabilities in fluid flow, Fluid-Fluid interfacial boundary conditions; Instabilities in Multiphase Flows: Kelvin-Helmholtz Instability, Rayleigh-Benard instability and Capillary Instability (Rayleigh-Pleatue); Stability of Parallel flows: Squires Theorem; The Rayleigh Stability Equation; The Orr-Sommerfeld Equation. Introduction to Turbulence; Basic definitions and concepts - averages and fluctuations; Correlations in velocity fluctuation; Frequency Spectra; Reynolds decomposition; Reynolds Average Navier-Stokes Equations (RANS); Reynolds Stresses; Introduction to Turbulent Viscosity; Overview of Mixing Length; Evolution of the Turbulent Kinetic Energy and its physical implications; Qualitative description of patterns in Turbulent flows: Vortex Stretching and Energy cascade; Kolmogorov Hypothesis and Kolmogorov Scales; Turbulence Modelling - The Closure Problem; Turbulent Viscosity Models: Zero Eqn.; One Equation and two Equation K-epsilon, k- omega models. Empirical laws: law of the walls.

Max 45 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Demonstrate the tensor notations for various fundamental concepts of basics of fluid mechanics.
CO2: Understand the complex flow problem and formulate the approximate governing equation to solve it.
CO3: Apply analytical/scaling procedures to solve fluid flow problems.
CO4: Understand the basic phenomena of fluid instability.
CO5: Analyze various turbulent flow problems/models.
CO6: Evaluate the complex fluid flow problems through numerical solutions.

TEXT/REFERENCE BOOKS

1. Muralidhar, Krishnamurthy, and Gautam Biswas. Advanced engineering fluid mechanics. Alpha Science Int'l Ltd., 2005.
2. PK Kundu, IM Cohen, Fluid Mechanics, Academic press 5th edition, 2012.
3. White, Frank M., and Isla Corfield. Viscous fluid flow. Vol. 3. New York: McGraw-Hill, 2006.
4. Schlichting, Hermann, and Klaus Gersten. Boundary-layer theory. Springer, 2016
5. Tennekes, Hendrik, John Leask Lumley, and Jonh L. Lumley. A first course in turbulence. MIT press, 1972.
6. Batchelor, George K. "An introduction to fluid dynamics. 1967

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part /Question: Questions from each unit with internal choice, each carrying 20 marks 100 Marks

20MET502T					Advanced Engineering Thermodynamics					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
3	**-**	**-**	**3**	**3**	**25**	**50**	**25**	**--**	**--**	**100**

COURSE OBJECTIVES

- 1 To understand and apply the thermodynamic laws to engineering thermodynamic systems.
- 2 To perform analysis of thermodynamic cycles and thermodynamics systems.
- 3 To understand, apply the principles of Equilibrium and non-equilibrium thermodynamics
- 4 To understand the microscopic and macroscopic perspective of entropy and exergy.

UNIT 1 **8 Hr**

Review of first and second law of thermodynamics, Maxwell equations, Joule-Thompson experiment, irreversibility and availability, exergy analysis, Thermo-economics. Ideal and real Gas Mixtures, Psychrometry

UNIT 2 **8 Hr**

Chemical thermodynamics: Reactive thermodynamics: Application to combustion, Ion-exchange-membrane of Fuel Cell. Third law of thermodynamics. Phase transition, types of equilibrium and stability

UNIT 3 **11 Hr**

Gas Power Cycles-- Ideal and Actual cycles, Cycles for IC Engines and Gas turbines, Combined 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. Actual vapour power cycles. Ideal and practical regenerative Rankine cycles, Reheat Rankine cycle. Refrigeration Cycles: Ideal Cycles, Vapour compression refrigeration system; Air cycle refrigeration; Vapour absorption refrigeration system, Steam jet refrigeration

UNIT 4 **13 Hr**

Statistical thermodynamics- introduction, energy states and energy levels, macro and microscales, thermodynamic probability, statistics, distribution function (B-E, F-D, M-D), partition energy, statistical interpretation of entropy, application of statistics to gases-mono-atomic ideal gas, Kinetic theory of gases.

Non-equilibrium Thermodynamics: Classical theory of irreversible thermodynamics, (theory of Eckart-Onsager-Prigogine), local equilibrium, balance laws and constitutive relations, entropy production, thermodynamic fluxes and forces, Onsager-Casimir reciprocal relations. Applications. Stationary states: criteria for minimum of entropy production and minimum of dissipated energy. Introduction to stability theory. Rayleigh-Bénard instability

Max : 40 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Apply first and second law analysis to open and closed systems

CO2: Understand and apply thermodynamics relations and laws to equilibrium/non-equilibrium systems.

CO3: Apply equations of state to make property calculations of Ideal/non-ideal /real gases;

CO4: To **understand**, develop and co-relate microscopic and macroscopic viewpoint/framework of entropy/exergy.

CO5: To **apply** principles of equilibrium and non-equilibrium thermodynamics for thermodynamics systems (both reactive and non-reactive).

CO6: Able to **apply** principles of statistical thermodynamics and non-equilibrium thermodynamics of various thermal system.

TEXT/REFERENCE BOOKS

1. Thermodynamics: an Engineering Approach, Y.A.Cengal and M.A.Boles, McGraw Hill (Fifth edition) 2018.
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. Modern thermodynamics: from heat engines to dissipative structures, Kondepudi, Dilip, and Ilya Prigogine. ,Wiley & Sons.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: Four questions (One from each unit) 40 Marks

Part B/Question: Four questions (One from each unit) 60 Marks

20MET503P					Thermal Lab - I		
Teaching Scheme					Examination Scheme		
L	T	P	C	Hrs/Week	Practical		Total Marks
					Continuous Evaluation	End Semester LE/Viva	
0	0	4	2	4	25	25	50

Course objectives:

- To **understand** wind tunnel experiment and performance with different geometries.
- To **understand, differentiate** and **analyze** different modes of heat transfer.
- To **estimate** performance of heat transfer systems.
- To **calculate** and **compare** the performance of heat exchangers.
- To **demonstrate** efficiency enhancement in different types of heat transfer strategies.

List of Experiments:

1. Experiments and performance test with different geometries- Airfoil shape.
2. Experiments and performance test with different geometries- Rectangular cross section.
3. Experiments and performance test with different geometries- Cylindrical cross section.
4. Numerical simulation of airfoil performance test.
5. Heat balance sheet of IC engine.
6. Conductive heat transfer experiment- conductivity of solid metal road.
7. Conductivity of powder sandwiched between two spheres.
8. Analysis of Convective heat transfer coefficient in Natural and Forced convection mode.
9. Shell and Tube Heat exchanger performance and analysis in parallel and counter flow mode.
10. Plate heat exchanger performance and analysis in laminar and turbulent flow conditions.
11. Software based numerical simulation of conductive heat transfer experiment.
12. Software based performance analysis of power plants.

Course Outcomes (COs): On completion of the course, students will be able to

CO1 - Understand drag and lift force for different geometries with experiment of wind tunnel.
CO2 - Understand and **analyze** conductivity of different materials.
CO3 - Examine the performance of heat exchangers.
CO4 - Evaluate the convective heat transfer coefficient.
CO5 - Demonstrate efficiency and performance enhancement in heat transfer equipment.
CO6 - Understand and **evaluate** different modes of heat transfer.

Resources/Text/Reference books

1. Houghton, Edward Lewis, and Peter William Carpenter, Aerodynamics for engineering students. Elsevier, 2003.
2. Ira H. Abbott and , A. E. von Doenhoff, Theory of Wing Sections, Dover Publications Inc.; New edition 1959.
3. P K Nag, Heat transfer, McGraw Hill Education; 3 edition, 2011.
4. Y A Cengel, Heat transfer, McGraw-Hill Education; 2 edition, 2002.

End Semester Lab Examination

Max. Marks: 25	**Exam Duration: 2 hrs**
Quiz/Experiment	10 Marks
Viva	15 Marks

20MET504T					Heating Ventilation and Air Conditioning					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To develop understanding of the operation of HVAC systems.
- To Impart knowledge of psychrometric and its application in HVAC engineering.
- To develop fundamental understanding how to determine heating and cooling, selection of air conditioning system and design of air distribution system.
- To know how to use ASHRAE and ISHRAE handbook for HVAC system design.

UNIT 1 INTRODUCTION AND PSYCHROMETRY **10 Hrs.**

Overview of Industry and Scope of HVAC - applications of HAVC - definitions and terminology. Psychrometry: Applied psychrometry - psychrometric processes using chart - basic psychrometric 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 2 HUMAN COMFORT AND COOLING LOAD ESTIMATION **12 Hrs.**

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 3 Air Distribution and Ventilation Systems **13 Hrs.**

Air Distribution: Ducts - Types of ducts - fundamentals of air flow in ducts - pressure drop calculations - duct design 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 4 AIR CONDITIONING SYSTEMS **10 Hrs.**

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 etc.

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - **Demonstrate** knowledge of thermal comfort conditions with respect to temperature and humidity and human clothing and activities and its impact on human comfort, productivity, and health.
CO2 - **Apply** thermodynamics and psychrometric principles to the analysis of indoor air properties and air conditioning processes.
CO3 - **Estimate** heating and cooling load for residential and automobile applications using ASHRAE and ISHRAE handbook.
CO4 - **Apply** principles of fluid mechanics and engineering for the analysis of duct and piping systems for air distribution systems and review associated turbomachines.
CO5 - **Design** ventilation system for cooling or heating of space.
CO6 - **Estimate** refrigeration system capacity for cold storage.

TEXT/REFERENCE BOOKS

1. ASHRAE Handbook - Fundamentals, American Society of Heating, Refrigerating and Air - Conditioning Engineers Inc., Atlanta, USA, 2009.
2. HVAC Handbook, ISHRAE and Refrigeration Handbook, ISHRAE.
3. Industrial Ventilation Application Handbook, ISHRAE
4. Croome, D.J. and Roberts, B.M., Air conditioning and ventilation of buildings (Vol-1), Pergamon Press, 1981.
5. Stoecker, W.F., and Jones, J.W., Refrigeration and Air Conditioning, Tata McGraw Hill, New Delhi, 2nd Edition, 1982.
6. McQuiston, Faye; Parker, Jerald; Spitler, Jeffrey, Heating, Ventilating and Air Conditioning-Analysis and Design, John Wiley & Sons, 5th Edition, 2000.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

10 Questions each of 10 marks from above units with appropriate marks distribution among designed Course Outcomes (COs) 100 Marks

20MET506T					Advanced Gas Dynamics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To get the overview of compressible fluid flow.
- To apply thermodynamic relations in a compressible fluid flow.
- To evaluate the change in pressure, density and temperature for flow through a normal and oblique shocks.
- To analyse the compressible flow in a duct with heat transfer and with friction.

UNIT 1 REVIEW OF FUNDAMENTALS **10 Hrs**

Review of fluid flow and thermodynamics; Compressible and incompressible flow, Ideal gas, speed of sound, Mach number, Effect of Mach number on compressibility, Entropy relations, velocity of sound and its importance, physical difference between incompressible, subsonic and supersonic flows, concepts of static and stagnation parameters. Adiabatic and isentropic flow of perfect gas, Isentropic relations; One-dimensional compressible adiabatic duct flow; choking, Area-Velocity relation, converging-diverging nozzles.

UNIT 2 NORMAL AND OBLIQUE SHOCKS **12 Hrs**

Introduction to normal and oblique shocks, Normal Shock on T-S diagram, Prandtl- Meyer relations, Fanno and Rayleigh lines, Rankine–Hugonout, Prandtl's and other relations, weak shocks, thickness of shocks, normal shocks in ducts, performance of convergent-divergent nozzle with shocks, Moving normal shocks, explosions and blast waves, piston-driven flow in pipes, expansion waves, reflecting shocks, x-t diagrams, shocks problems in one dimensional supersonics diffuser, supersonic pilot tube. 2D compressible flow - Oblique shocks, compression waves, reflecting oblique shocks, expansion waves, supersonic wings.

UNIT 3 RAYLEIGH AND FANNO FLOW IN A DUCT **12 Hrs**

Flow through constant area duct with heat transfer - Rayleigh flow and equations, Rayleigh line on h-s, P-v diagram and T-s diagrams, choked Rayleigh flow, Fanno flow - Flow in a constant area duct with friction, choked Fanno flow. 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 4 ADVANCED TOPICS ON GAS DYNAMICS **8 Hrs**

Multidimensional flow, potential flow, Method of characteristics. Dimensional analysis and similarity: Buckingham pi theorem, Van driest theorem, compressible flow of viscous fluids. Rarefied gas dynamics: Microscopic description of the gas, Knudsen number, sleep flow, transition and free molecular flow. Circulation theorem, Crocoo's theorem, Boltzmann Distribution, High temperature flows. Shockwave applications in Industry - in variety of areas such as medicine, biological sciences, material processing, manufacturing, and microelectronic industries.

Max : 40 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Apply the basic thermodynamic relations in compressible fluid flows.
CO2: Understand the characteristics of normal and oblique shock Waves.
CO3: Comprehend the flow through duct with heat transfer - Rayleigh flow.
CO4: Understand the flow through duct with friction **-** Fanno flow.
CO5: Recognize several characteristics of the two-dimensional compressible fluid flows.
CO6: Apply principles of dimensional analysis and analyse microscopic description of the gas in high temperature.

TEXT/REFERENCE BOOKS

1. Fundamentals of Gas dynamics, Robert D. Zucker and Oscar Dibllurz, JOhn Wiley and Sons, INC. 2nd edition, 2002.
2. Anderson, John David. Modern compressible flow. Vol. 12. New York: McGraw-Hill, 1990.
3. Oosthuizen, Patrick H., and William E. Carscallen. Introduction to compressible fluid flow. CRC press, 2013.
4. S.M. Yahya, Fundamentals of Compressible Flow, New Age International Private Limited; 5th edition 2016.
5. Radha Krishnan, Gas Dynamics, Prentice Hall India Learning Private Limited; 5th Revised edition, 2014.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part /Question: Questions from each unit with internal choice, each carrying 20 marks 100 Marks

20MET507T					Introduction to Aircraft Flight and Aerodynamics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To understand the basics of aircraft flight and its aerodynamics.
- To evaluate the aircraft equation of motion and its performance.
- To demonstrate the aircraft stability and its control.
- To understand the working of several aircraft engines

UNIT 1 INTRODUCTION TO BASIC AERODYNAMICS **10 Hrs**

Basic continuity and momentum equation, Incompressible and Compressible Flow, Isentropic Flow, Energy equation, Wind tunnels, Compressibility, Laminar and turbulent boundary layer, Flow separation, Drag, Angle of attack.

UNIT 2 AIRFOILS AND WINGS **10 Hrs**

Airfoil nomenclature, Lift, drag and moment coefficient, Infinite and finite wings, Pressure co-efficient, Compressibility correction, Critical Mach number, Wave drag, Induced drag, swept wings, Flaps, Aerodynamics of cylinders and spheres.

UNIT 3 AIRCRAFT PERFORMANCE **10 Hrs**

Aircraft equation of motion, Thrust required for level flight, Thrust available, Maximum velocity, Power required for level flight, Altitude effect on power required, Rate of climb, Gliding flight, Absolute and service ceilings, Time of climb, Range and endurance, Landing and take-off performance. Turning of flight, V-n diagram.

UNIT 4 AIRCRAFT STABILITY, CONTROL AND PROPULSION **12 Hrs**

Introduction to aircraft stability and control, Moments on airplanes, Angle of attack, Longitudinal static stability, Pitching moment, Equation of longitudinal static stability, Neutral point, Static margin, Static longitudinal control, Trim, Stick-fixed and stick-free static stability. Propeller and jet propulsion, Turbojet engine, Turbofan engine, Ramjet engine, Rocket engine.

Max : 42 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Understand the basics of aerodynamics.
CO2: Distinguish the airfoil nomenclature and its characteristics.
CO3: Develop the equation of motion of aircraft and its performance.
CO4: Analyze several performance characteristics of an aircraft.
CO5: Assess the aircraft stability and control characteristics.
CO6: Classify several types of aircraft propulsion engines.

TEXT/REFERENCE BOOKS

1. John Anderson, Introduction to flight, McGraw-Hill Education; 8 edition 2015.
2. Ira H. Abbott and , A. E. von Doenhoff, Theory of Wing Sections, Dover Publications Inc.; New edition 1959.
3. Saeed Farokhi , Aircraft Propulsion, Wiley publishing, 2nd edition 2014.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part /Question: Questions from each unit with internal choice, each carrying 20 marks 100 Marks

20MET505T					Cryogenic systems					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- Provide the fundamental knowledge of fluid and material properties at cryogenics temperature & its application
- Provide the knowledge of various cryogenic gas liquification and air separation system
- Knowhow the working of cryogenic refrigerator & cryocoolers and estimate it's performance
- Perform the design cryogenic storage vessel and evaluate the effect of various insulation during design

UNIT 1 Fluid and material properties at low temperature & applications of cryogenics 9 Hr

Introduction to cryogenics: Cryogenic temperature scale, Properties of cryogenic fluids, super fluidity of He3 & He 4, properties of engineering materials at cryogenic temperatures, mechanical properties, thermal properties, electric & magnetic properties, super conducting materials. Applications of cryogenic systems: Super conductive devices, space technology, space simulation, cryogenics in biology and medicine, food preservation and industrial applications, nuclear propulsions, chemical propulsions

UNIT 2 Cryogenic Gas liquification and air-separation system 12 Hr

Gas liquefaction systems: Introduction, thermodynamically ideal systems, Joule Thomson effect, liquefaction systems such as Linde Hampton, precooled Linde Hampson, Linde dual pressure, cascade system, Claude system, Kapitza system, Heyland systems using expanders, comparison of liquefaction systems and its performance evaluations. Basics of Gas Separation, Ideal Gas Separation System, Gibbs Phase Rule, Phase Equilibrium Curves, Temperature Composition Diagrams, Raoult's Law, Gibbs – Dalton's Law, Distribution Coefficient, Enthalpy composition diagrams, Rectification Column Murphree efficiency, Theoretical Plate Calculations

UNIT 3 Cryogenic refrigerator and cryocoolers 12L Hr

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, Sterling refrigerators, Importance of regenerator effectiveness for the Sterling refrigerators, Gifford single volume refrigerator, Gifford double volume refrigerators analysis, Refrigerators using solids as working media: Magnetic cooling, magnetic refrigeration systems, thermal; valves, nuclear demagnetization, dilution refrigerator

UNIT 4 Cryogenic fluid storage, instrumentation, and insulation 12 Hr

Dewar vessel for cryogenic fluid storage, Construction, Inner vessel design, outer vessel design, Temperature measurements, pressure measurements, flow measurements, liquid level measurements, fluid quality measurements, 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.

Lecture: 45 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: **Recall** and **list** the properties of cryogenic fluids, Identify the behaviour of material properties at low temperature and application of cryogenics.
CO2: **Classify** the various cryogenic liquification systems and evaluate its performance.
CO4: **Understand** the working of various cryogenic refrigeration & cryocoolers and analysed its performance.
CO5: **Analyze** and **evaluate** the cryogenic gas separation system.
CO6: **Perform** the design of cryogenic storage vessel and evaluate the effect of various cryogenics insulations.

TEXT/REFERENCE BOOKS

1. Cryogenic systems, R F Barron, Oxford University Press, 2nd edition, 1985.
2. Cryogenics: A Text Book, S. S. Thipse, Alpha Science Intl Ltd, 1st edition, 2013.
3. Cryogenic technology & applications, A R Jha, Butterworth-Heinemann, 2006.
4. Cryocooler, Fundamentals Part I &II, Graham Walker, Plenum Press, New York, 1st edition,1983.
5. Fundamentals of Cryogenic Engineering, Mamata Mukhopadhyay, PHI. 1st edition 2010.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: Questions from each unit with internal choice, each carrying 20 marks 100 Marks

20MET508T					Energy Management					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	4	25	50	25	--	--	100

COURSE OBJECTIVES

- Learn the present energy scenario and concept of sustainable energy
- Impart knowledge on energy conservation techniques for energy management
- To implement energy conservation techniques in process industries and assess the impact
- To inculcate knowledge and skills to identify, formulate and solve fields problem in a multi-disciplinary frame individually or as a member of a group

UNIT 1: ENERGY CLASSIFICATION AND INTRODUCTION TO CONCEPT OF SUSTAINABILTY 10 Hrs

Global & National energy scenarios, Need for energy management, Energy classification- Primary & Secondary energy, commercial & non-commercial energy, non-renewable & renewable energy, primary energy resources, commercial energy production, energy conservation and its importance Non-Renewable energy and their impact on the ecology, Key factors in the exploitation, production and use; Sustainability in energy production and usage; Energy security

UNIT 2: ENERGY MANAGEMENT FOR THERMAL AND ELECTRICAL UTILITIES 10 Hrs

Energy Management for thermal utilities such as Boiler, furnace, Insulation & Refractories, Heat exchangers. Energy Management for electrical utilities such as Electric motor, Air compressed system, HVAC and refrigeration system, Fans & Blowers, Pumps & Pumping System, Cooling towers, Occupancy sensors, Energy efficient lighting controls, Case studies

UNIT 3: HEAT RECOVERY SYSTEMS 12 Hrs

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

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

UNIT 4: APPLICATION OF ENERGY MANAGEMENT AND ITS IMPACT IN REAL CASE SCENARIOS 10 Hrs

Energy Management within buildings, Thermal Insulation, Concept of smart grid, Tariff, Energy Data Analysis using Smart Energy Systems, Market Opportunities, Innovations and Best Practices, Energy Auditing, Industrial case studies – assessment of energy generation/consumption in thermal station, steel industry, cement industry, sugar industry, etc.

Max: 42 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: **Define** different forms of energy and **list** advantages and disadvantages of different sources of energy

CO2: To **illustrate** the need for energy management and control strategies and **identify** opportunities for enabling rational use of energy by developing energy efficient systems from supply and demand perspective.

CO3: To **design** and **develop** heat recovery systems for optimal performance.

CO4: **Inspect** and **analyze** the performance of thermal and electrical utilities.

CO5: **Assess** and **recommend** methods to improve the overall efficiency for different energy intensive industries.

CO6: **Develop** skills to **create** innovative energy efficiency solutions, and **formulate** demand management strategies.

TEXT/REFERENCE BOOKS

1. Kothari, D.P., Singal, K.C. and Ranjan, R., Renewable energy sources and emerging technologies, PHI Learning Pvt. Ltd., 2011
2. Kreith F. and Goswami D. Y., Energy Management and Conservation Handbook, 2nd edition, CRC press, 2016
3. Zobaa, A.F. and Bansal, R.C., Handbook of renewable energy technology, World Scientific, 2011
4. Shenoy, U. V., Heat Exchanger Network Synthesis- Process Optimization by Energy and Resource Analysis, Gulf Publ. Company, 1995

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 10 Questions from each unit, each carrying 2 marks 20 Marks

Part B/Question: 2 Questions from each unit with internal choice, each carrying 16 marks 80 Marks

COURSE STRUCTURE FOR M.TECH. MECHANICAL FIRST YEAR Sem II (Thermal Engineering)

w.e.f 2020-21

SEMESTER II (Subjects)			M.TECH. Sem. – II (Thermal)										
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	20MET509T	Experimental Methods in Thermal Engineering	3	0	0	3	3	25	50	25	--	--	100
2	20MET510T	Advance Heat Transfer	3	0	0	3	3	25	50	25	--	--	100
3	20MET511T	Computational Fluid Dynamics	3	1	0	4	4	25	50	25	--	--	100
4	20MET512P	Thermal Lab-II	0	0	4	2	4				25	25	50
5		Elective III	3	0	0	3	3	25	50	25	--	--	100
6		Elective IV	3	0	0	3	3	25	50	25	--	--	100
7	17CE527T	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) Heat Transfer Equipment Design (i) 16ME514T: Design and Optimization of Thermal Systems (ii) 16ME515T: Convective Heat Transfer

Elective IV: (i) 16ME516T: Solar Thermal Systems (ii) 20MEXXXT: Recent Applications of Cavitation Technology in Industry

20MET509T					Experimental Methods in Thermal Engineering					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- Understanding of various experimental techniques use in thermal engineering.
- Understanding of various measurement techniques in thermal engineering.
- Analyze and interpret experimental data.

UNIT 1 **10 Hr**

Introduction, Details of an experimental setup, Static versus dynamic calibration, Design of experiments, Analysis of experimental data, Response surface methodology, Central limit theorem, uncertainty analysis, propagation of uncertainty, types of errors, Error propagation. Use of MINITAB and MATLAB for experiment design and data analysis.

UNIT 2 **12 Hr**

Statistical analysis of experimental data-normal error distributions (confidence interval and level of significance, Chauvenet's criterion), Chi-square test of goodness of fit, method of least squares (regression analysis, correlation coefficient), multivariable regression, Students' t-distribution, graphical analysis and curve fitting. Static and dynamic characteristics. Use of MINITAB and MATLAB for Statistical analysis

UNIT 3 **11 Hr**

Introduction to measurements, Measurement categories-primary and derived quantities, intrusive and non-intrusive methods, Measurement of temperature- temperature sensors for measurement of transient temperature; Measurement of pressure, measurement of transient and vacuum pressures. Measurement of volume flow rate, Measurement of velocity

UNIT 4 **12 Hr**

Data acquisition systems: Analog input-output communication, Analog to digital converter, static and dynamic characteristic of signals, Bits, Transmitting digital numbers, resolution, quantization error, signal connections, single and differential connections, signal conditioning. Digital signal with digital image processing, Treatment of periodic data, Inverse techniques: Determination of thermo physical properties using inverse techniques.

Lecture: 45 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: **Understand** and Implement the design of experiments
CO2: **Utilize** the different experimental techniques to analyze and understand experimental data
CO3: **Analyze** the significance of experimental results through statistical techniques
CO4: **Classify** the various measurement systems, compare their performance and list its application.
CO5: **Understanding** the construction and working of various measurement system of thermal engineering
CO6: **Demonstrate** the experimental data analysis through data acquisition and implement the inverse techniques

TEXT/REFERENCE BOOKS

7. J. P. Holman, Experimental Methods for Engineers, 8th edition, Tata McGraw-Hill 2011
8. Douglas C. Montgomery, Design and Analysis of Experiments, 10th Edition, Wiley, 2019
9. E.O. Doebelin, Measurement systems, Application and Design, 5th edition, TataMcGraw-Hill, 2008

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: Questions from each unit with internal choice, each carrying 20 marks 100 Marks

20MET510T					Advanced Heat Transfer					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	-		4	25	50	25	--	--	100

COURSE OBJECTIVES

- To study and analyze the basics of three modes of Heat Transfer (HT).
- Apply scientific and engineering principles to analyze and design HT aspects of engineering systems.
- Study and apply different solution methods and choose appropriate analytical or approximate or order-of-magnitude-analysis or computational tools to investigate heat transport phenomena.
- To develop HT models and computational strategies to solve and analyze the HT physics.

UNIT 1 **12 Hrs.**

Conduction Heat transport: General Conduction based Governing Equation. Non-dimensionalization, Fourier and non-Fourier heat transfer. Analytical and numerical procedures to multi-dimensional steady conduction problems. Unsteady Conduction heat transfer problems: Lumped analysis with heat generation, unsteady heat transfer in semi-infinite and finite body.

UNIT 2 **15 Hrs.**

Radiation Laws, Concept of Radiosity, Solution of multi-enclosure problems using network method, Radiation Intensity, Solid-angle, Scattering (In and out), attenuation, and augmentation of Intensity Radiation Transfer Equation. Derivation of shape-factors and its evaluation procedures.

UNIT 3 **13 Hrs.**

Introduction to convection: Derivation of governing equations for convective heat transport. Convective heat transfer in laminar and turbulent flows, Solution & analysis procedures for Turbulent heat transfer. Solution of Forced Convection problems (Internal/external) using Theoretical/numerical procedures.

UNIT 4 **15 Hrs.**

Free convection: Free convection boundary layer equations, Analytical, approximate and numerical solutions procedures for internal and external free convection; Rayleigh-Benard convection, Onset of convection. Application of empirical correlations to estimate Nusselt Number/heat-transfer coefficient. Complex and Multi-mode heat transfer: Phase-change heat transfer, Turbulent heat transfer computation model, Participating-medium radiation heat transfer.

Total: 55Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to,

CO1 - **Understand** and **apply** the basic concept of conduction, convection and radiation heat transfer.
CO2 – **Sketch** the equivalent-thermal-circuit/simplified-HT-system to **solve** and **analyse** complex HT problems.
CO3 – **Choose/Derive/Formulate** the right governing equation and solution procedure for Complex HT problems.
CO4 – **Formulate** and/or **apply** the numerical strategy to solve heat transfer problem
CO5 – **Compare** the magnitude of different terms in Governing Equation (GE) and construct and solve simplified GE.
CO6 – **Evaluate** the Radiation heat transfer in engineering system with/without participating medium.

TEXT/REFERENCE BOOKS

1. Conduction Heat Transfer, V.S. Arpaci, Addison Wesley, 1996 (Abridged edition Ginn press 1998)
2. Burmeister, Louis C. Convective heat transfer. John Wiley & Sons, 1993.
3. Bejan, Adrian. Convection heat transfer. John wiley & sons, 2013.
4. Radiative Heat Transfer, M.F.Modest, McGraw Hill, 2003.
5. Bergman, T. L., Incropera, F. P., *et. al.* (2011). Introduction to heat transfer. John Wiley & Sons.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/ Four questions (One from each unit) 20 Marks
Part B/ Four questions (One from each unit) 80 Marks

20MET511T					Computational Fluid Dynamics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	--	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

- To numerically **solve** governing partial differential equations for transport processes.
- To **analyze** different mathematical models and computational methods for transport processes.
- To **study**, and **apply** discretization methods & schemes and analyze its effect on the accuracy of numerical solution and computational time.
- To **demonstrate** the ability to use modern CFD software tools.

UNIT 1 Introduction to Computational Fluid Dynamics and Finite Difference method 8 Hrs.

Introduction to Computational Fluid Dynamics. Classification into various types of equations parabolic, elliptic, hyperbolic and mixed type; Boundary and initial conditions; Overview of numerical methods. Finite Difference Method - explicit, implicit, stability requirement, boundary conditions. Errors and analysis of stability – perturbation stability analysis and Von-Neumann stability analysis.

UNIT 2 Finite volume method 8Hrs.

Finite volume method for general transport convection/diffusion equations. Discretization of transient, advection, diffusion and source terms, and spatial discretization of domain. Solution strategies for solving of system of algebraic equations, residual error, convergence, under-relaxation.

UNIT 3 Pressure-velocity coupling, temporal discretization schemes and advance topics 8 Hrs.

Solution algorithms for pressure-velocity coupling. Staggered/Collocated grid concepts; Temporal discretization schemes—Implicit and explicit approach. Analysis of numerical discretization schemes consistency, stability, boundedness, error-analysis. Grid transformation and grid generation methods. Special topics in CFD.

UNIT 4 Hand-on: CFD using Computer Software 12 Hrs.

Introduction and Application of modern CFD-toolbox/software OpenFOAM/Dolfyn/ANSYS/FLUENT/STAR-CCM+/MATLAB: Geometric modelling, mesh generation, boundary and initial conditions, computational approach, analysis. Engineering case studies using CFD: Numerical simulation of steady un-steady process of transport phenomena in engineering process. Post-processing of results.

Max. 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - **Solve** the governing partial differential equations of fluid flow and heat transfer problems.
CO2 - **Construct** and **solve** the different mathematical models and computational methods for fluid flows.
CO3 - **Apply** the discretization methods to solve fluid flow and heat transfer problems.
CO4 - **Choose and Justify** the CFD schemes for the respective fluid flow/transport phenomena problem.
CO5 - **Perform** verification and validation of numerical model.
CO6 - **Demonstrate** the ability to use modern CFD software tools.

TEXT/REFERENCE BOOKS

1. Patankar, Suhas. Numerical heat transfer and fluid flow. Taylor & Francis, 2018.
2. Introduction to Computational Fluid Dynamics: The Finite Volume Method, Versteeg, H. K. and Malalasekara, W., Second Edition (Indian Reprint) Pearson Education, 2008.
3. Computational Fluid Dynamics (Vol. 1) 4th Edition by Klaus A. Hoffmann & Steve T. Chiang , Engineering Education System 2000.
4. Computational Fluid Dynamics, J. D. Anderson Jr., McGraw-Hill International Edition, 1995.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 10 Questions from unit I and Unit II 25 Marks
Part B/Question: 15 Questions from Unit III (Unit IV will be counted in IA) 75 Marks

20MET512P					Thermal Lab II		
Teaching Scheme					Examination Scheme		
L	T	P	C	Hrs/Week	Practical		Total Marks
					Continuous Evaluation	End Semester LE/Viva	
0	0	4	2	4	25	25	50

Course objectives:

- **To analyze, differentiate** and **evaluate** different modes of heat transfer through various mediums and model it for particular application
- **To evaluate** steady and transient state properties of heat transfer mediums.
- **To calculate and compare** the performance of heat exchangers.
- **To demonstrate** boiling and condensation regimes

List of Experiments:

1. Natural Convective heat transfer experiment and modeling.
2. Forced Convective heat transfer experiment
3. Radiative heat transfer experiment and modeling.
4. Compact heat exchanger performance test.
5. Solar thermal experiment.
6. To calculate the heat loss from a lagged pipe
7. The determination of the thermal conductivity of fluids
8. To study the two phases heat transfer
9. To study Dropwise and Film-wise condensation process
10. To measure the critical heat flux of a Nichrome wire
11. Study and parametric investigation of 5 kW Semi-Hermetic Scroll Expander for Organic Rankine Cycle (ORC) applications.
12. Performance of Engine with different blend ratios of bio-diesel.
13. Steam condensation through heat transfer without fins and with fins

Course Outcomes (COs): On completion of the course, students will be able to

CO1 - Understand and **evaluate** different modes of heat transfer.
CO2 - Understand and **analyze** conductivity of different fluids.
CO3 - Examine the performance of heat exchangers.
CO4 - Evaluate the convective heat transfer coefficient
CO5 - Demonstrate film wise and dropwise condensation and **evaluate** their performance.
CO6 - Interpret and **evaluate** critical heat flux (CHF)

Resources/Text/Reference books

1. P K Nag, Heat transfer, McGraw Hill Education; 3rd edition, 2011.
2. Y A Cengel, Heat transfer, McGraw-Hill Education; 2nd edition, 2002.

End Semester Lab Examination

Max. Marks	**Exam Duration: 2 hrs**
Quiz/Experiment	10 Marks
Viva	15 Marks

20MET513P					Heat Transfer Equipment Design					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- Understanding of construction, working and application of various heat transfer equipment's
- Perform the thermal and hydraulic design of various heat exchangers
- Perform the design of natural draft and mechanical draft cooling tower
- Explain rating and selection of various refrigeration components and perform the design of heat pipe.

UNIT 1 Tabular Heat Exchanger Design **12 Hr**

Review of basics of heat exchanger, rating and sizing problems, Basic components, TEMA standard, Classification as per TEMA standard, Thermal Design Theory for shell and tube heat exchanger, as per Kern and Bell-Delaware method, hydraulic design of shell and tube heat exchanger as per Kern method, Bell-Delaware method, HTRI software for Shell and tube heat exchanger design

UNIT 2 Recuperative & Regenerative Type Compact Heat Exchanger Design **12 Hr**

Thermal design of plate-fin heat exchanger, fin and tube heat exchanger and plate heat exchanger, Estimation of pressure drop and hydraulic design of plate-fin, fin and tube, and plate heat exchange. Effect of geometric parameters and operating parameters on performance of heat exchanger. Assumptions for Regenerator Heat Transfer Analysis, Governing Equations, the Λ-Π method for regenerator design, Influence of Matrix Material, Size, and Arrangement, Influence of longitudinal and transverse heat conduction

UNIT 3 Cooling Tower Design **11 Hr**

Basic of Cooling Tower, Components of a natural draft and forced draft cooling Tower, Tower materials, Factors govern the operation of cooling tower, types of cooling tower, Basic terminology of cooling tower design, thermal design of mechanical draft cooling tower, Air rate, gas phase enthalpy transfer unit, Equilibrium line, Operating line, Improving Energy Efficiency of Cooling Towers, make-up water calculation, Design of natural draft counter flow cooling tower

UNIT 4 Refrigeration Components and Heat Pipe Design **10 Hr**

Refrigerator component selection and design: Rating and selection of evaporator, compressor air- and water-cooled condenser, evaporator, and expansion valve. Heat pipe design: Basics of heat pipe, Heat pipe component and materials, working fluids, material selection for heat pipe, Wick structure of heat pipe, sonic limit, entrainment limit, wicking limit, thermal design of heat pipe, special types of heat pipe

Lecture: 45 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: **Understand** the types, construction, main parts, working and applications of various heat exchangers.
CO2: **Utilize** TEMA standard and execute the design of tabular exchangers
CO3: **Design** and analyze the recuperative type compact heat exchanger
CO4: **Demonstrate** the regenerative heat exchanger design and evaluate its performance.
CO5: **Estimate** the performance of cooling tower through its thermal design
CO6: **Understand** rating and section of refrigeration components and analyze the performance of heat pipe

TEXT/REFERENCE BOOKS

1. R.K.Shah, P. Sekulic, Fundamentals of Heat Exchanger Design, John Willey
2. Sadik Kakac, Hongtan Liu, Heat exchanger-selection, rating and thermal design, CRC press
3. Roy. J. Doosat, Principles of Refrigeration, Pearson
4. Eric M. Smith, Advances in thermal design of heat exchangers, Willey.
5. W.M. Kays, A.L. London, Compact heat exchangers
6. VK Patel, VJ Savsani, MA Twahid, Thermal system design optimization, Springer Nature

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: Questions from each unit with internal choice, each carrying 20 marks 100 Marks

20MET514					Design and Optimization of Thermal Systems					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To impart the knowledge of steps involve in thermal system design-optimization
- To perform the modeling and optimization of thermal systems
- To identify the proper optimization techniques for given system and implement it

UNIT 1 **10 Hr**

Introduction, thermal systems, engineering design, workable and optimal designs. primary energy analysis, basic considerations in design, conceptual design, steps in the design process, Design criteria: maximum efficiency and energy conservation, minimum cost/losses, multi-criteria, functional reliability of system components, types of models with examples, mathematical modelling of processes and components, system models, identification of operating variables;

UNIT 2 **12 Hr**

Modelling and simulation of thermal systems, simulation techniques, System Simulation, Classification, Successive substitution method-examples, Newton-Raphson method, Gauss Seidel method, Need for regression in simulation and optimization. Concept of best fit and exact fit. Exact fit- Lagrange interpolation, Newton's divided difference. Least square regression, linear regression, Power law forms, Gauss Newton method for non-linear least squares regression

UNIT 3 **12 Hr**

Formulation of optimization problems, Calculus techniques: Lagrange multiplier method. Search methods: Concept of interval of uncertainty, reduction ratio, reduction ratios of simple search techniques like exhaustive search, dichotomous search, Fibonacci search and Golden section search, Method of steepest ascent/steepest descent, conjugate gradient method. Case study analysis using above methods using MATLAB and ANSYS Software.

UNIT 4 **11 Hr**

Geometric programming, dynamic programming. Non-traditional optimization techniques: Genetic algorithm, simulated annealing, heat transfer search algorithm, Application of these methods to optimization of different thermal system. Case study analysis using above methods using MATLAB and ANSYS Software.

Lecture: 45 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: **Enlist** the types & steps involve in the thermal system design-optimization.
CO2: **Utilize** the modelling of thermal system.
CO3: **Develop** an objective function and appropriate constraints for a complete thermal system optimization problem.
CO4: **Understand** the various constraint and unconstraint optimization techniques.
CO5: **Apply** different methods for the optimization of thermal system.
CO6: **Understand** and Implement the non-traditional optimization techniques.

TEXT/REFERENCE BOOKS

1. W.F. Stoecker, Design of Thermal Systems, McGraw Hill
2. Y. Jaluria, Design and Optimization of Thermal Systems, CRC Press
3. R.F. Boehm, Developments in the design of thermal systems, Cambridge University Press
4. S.G. Penoncello, Thermal Energy Systems Design and Analysis, CRC Press
5. Essentials of Thermal system Design and Optimization, C. Balaji, Ane Books Pvt. Ltd.
6. hermal System Design and Simulation, P L Dhar, Academic Press

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: Questions from each unit with internal choice, each carrying 20 marks 100 Marks

20MET515P					**Convective Heat Transfer**					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
3	**1**	**-**		**4**	**25**	**50**	**25**	**--**	**--**	**100**

COURSE OBJECTIVES

- To study and analyse the basics of Convective Heat Transfer (CHT).
- Apply scientific and engineering principles to analyse and design CHT aspects systems.
- Study and apply different solution methods and choose appropriate analytical or or approximate or order-of-magnitude-analysis or computational tools to investigate convective heat transport phenomena.
- To develop and analyse CHT problems and study multimode CHT physics.

UNIT 1 9 Hrs.

Introduction to convection: Derivation of governing equations of momentum, energy and species transport, Order of magnitude analysis, Reynolds analogy. Introduction to turbulent convective heat transfer, Reynolds averaging, Eddy viscosity and eddy thermal diffusivity, Laws of the wall. Convection in internal flows: Concept of developing and fully developed flows.

UNIT 2 10 Hrs.

Thermally developing flows: Graetz problem. Concept of thermally fully developed flow and its consequences under constant wall flux and constant wall temperature conditions, Steady forced convection in Hagen Poiseuille flow, Plane Poiseuille flow, and Couette flow and analytical evaluation of Nusselt numbers in limiting cases.

UNIT 3 10 Hrs.

Convective heat transfer in external flows: Derivation of hydrodynamic and thermal boundary layer equations, Similarity solution techniques, Momentum and energy integral methods and their applications in flow over flat plates with low and high Prandtl number approximations.

UNIT 4 11 Hrs.

Free convection boundary layer equations: order of magnitude analysis, similarity and series solutions, Concept of thermal stability and Rayleigh Benard convection.
An introduction to convective transport in micro/meso-scales, Conjugate problems and moving boundary, Marangoni-convection, Phase-change convective heat transfer systems. An introduction to convective mass transfer in binary systems: analytical solutions to simple one dimensional problems

Total: 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to,

CO1 - Understand and apply the basic concept and Governing equation of convection heat transfer.
CO2 - Solve and perform analysis of Forced Convection Engineering problems.
CO3 - Solve and perform analysis of Natural Convection Engineering problems.
CO4 - Learn and **develop** the ability to non-dimensionalize the governing equation and then Formulate a solvable Approximate Governing Equation.
CO5 - Classify the complex CHT problem; Solve and analyse Turbulent heat transfer problems
CO6 - Demonstrate analytical/theoretical/numerical procedures to solve the Convective heat transfer Engineering problems.

TEXT/REFERENCE BOOKS

1. Kays, William Morrow. Convective heat and mass transfer. Tata McGraw-Hill Education, 2012.
2. Burmeister, Louis C. Convective heat transfer. John Wiley & Sons, 1993.
3. Bejan, Adrian. Convection heat transfer. John wiley & sons, 2013.
4. Kakac, Sadik, Yaman Yener, and Anchasa Pramuanjaroenkij. Convective heat transfer. CRC press, 2013.
5. Bergman, T. L., Incropera, F. P., *et. al.* (2011). Introduction to heat transfer. John Wiley & Sons.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**
Part A/ Four questions (One from each unit) 20 Marks
Part B/ Four questions (One from each unit) 80 Marks

20MET516P					Solar Thermal Systems					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To introduce and define the basics concept of solar radiation.
- To familiarize with thermal modelling, construction and working principles of concentrated and non-concentrated collectors.
- To enable the students to understand the details about the solar thermal power generation system.
- To demonstrate the working and calculations involved in design and analysis of heating and cooling systems for Industrial applications.

UNIT 1 SOLAR ENERGY **8 Hrs**

Sun; Solar geometry; Solar Spectrum; .Extra-terrestrial and terrestrial radiation, Solar radiation over different surfaces; Day-length, sunrise and sunset calculation; Measurement of solar radiation; solar radiation data; Assessing weather data files; Introduction to Modelling using EnergyPlus/ TRNSYS/ EES tools.

UNIT 2 SOLAR COLLECTORS **10 Hrs**

Flat plate collectors, thermal efficiency, heat removal factor, Incidence Angle Modifier; PCM assisted Flat plate Collectors; Evacuated tube collector; Concentrating Collectors: Collector Configurations - Concentration Ratio - Thermal Performance of Concentrating Collectors - Optical Performance of Concentrating Collectors; Parabolic Trough Collectors (PTC), Parabolic dish collectors, Linear Fresnel reflectors, Central receiver. Solar Thermal Storage: Sensible heat storage – Phase change material based storage – chemical storage. System Thermal Calculations: Collector Heat Exchanger Factor - Duct and Pipe Loss Factors - Collector Arrays - Solar Fraction and Solar Savings Fraction.

UNIT 3 SOLAR HEATING APPLICATIONS **14 Hrs**

Solar water heater; Thermal modelling of PCM assisted solar water heating; PCM assisted solar drying concept; Application of solar drying in industries; Solar cooking; Solar desalination; Water purification using solar technology; Solar assisted building heating systems; Design of a solar heating system; Industrial applications and Case Studies; Solar Thermal Power generation and its economic analysis.

UNIT 4 SOLAR ASSISTED COOLING AND REFRIGERATION SYSTEMS **10 Hrs**

Solar assisted VCR systems, Vapour absorption cooling: Open cycle systems, closed cycle systems, multistage systems; Vapour adsorption cooling: Open cycle, Closed cycle, hybrid-cooling systems; Solar thermoelectric refrigeration; Solar assisted thermal regulation; Application potential for solar cooling and refrigeration; Economic considerations of solar cooling systems.

Max. 42 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Understand the terms of earth-sun geometry and analyse the availability of solar radiation at various locations.
CO2: Understand and explain the modelling, construction and working of different solar collectors.
CO3: Design and analyse the solar thermal systems.
CO4: Utilization of appropriate solar thermal storage and carry out economic analysis.
CO5: Design and integration of solar heating systems for various applications.
CO6: Compile the information solar air conditioning and refrigeration systems.

TEXT/REFERENCE BOOKS

1. Duffie J. A, Beckman W. A., Solar Engineering of Thermal Processes, Wiley, 4th edition, 2013
2. Sukhatme S. P., Nayak, J. K., Solar Energy-Principles of Thermal Collection and Storage, Tata McGraw Hill, 4th edition, 2017
3. Goswami D. Y., Principles of Solar Energy, CRC Press,3rd edition, 2015
4. Kaushik S.C., Solar Refrigeration and Air Conditioning, Divyajyoti Prakashan, 1989
5. German Solar Energy Society, Planning and Installing Solar Thermal Systems- a guide for installers, architects and engineers, 2nd edition, 2010.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 10 Questions from each unit, each carrying 2 marks 20 Marks
Part B/Question: 2 Questions from each unit with internal choice, carrying 16 marks 80 Marks

20MET517P					Recent Applications of Cavitation Technology in Industry					
Teaching Scheme					**Examination Scheme**					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- Introduction to cavitation technology (CT) and its industrial applications.
- Understand application of CT for renewable fuel production methods.
- Appreciate the application of CT drinking water and waste water management.
- Aware of recent miscellaneous examples of CT in Industry.

UNIT 1 <Fundamentals of Cavitation Technology> 12_ Hrs.

< Fundamental mechanism of Cavitation; physical concept and flow visualization; cavitation parameters; complexities and involvement of conjoint fields; classification of CT devices : Ultrasound; Microwave; Hydrodynamic, SWPR, Jet pump Cavitation reactor, Vortex based reactors, high speed fruit grinder and other Process intensification techniques; System specification, construction and working, Design Aspects; Mechanisms: Overview and Industrial applications.>

UNIT 2<Renewable fuel production> 12_ Hrs.

< Renewable fuels: Policies; circular economy; Classification; Biodiesel and Ethanol production; Algae; Process Intensification reactors; Case studies. Refinery Concept; Application of CT for biogas production, biomass and agriculture waste utilization. Extraction and oil refining techniques;

Conventional Fuels: Coal ultrasound; Coal water(cavitation activated) slurry fuels; Sono-hydro-Gen-Process; treatment of oily sludge; Upgrading of heavy oils using CT, desulfurization of Diesel; current applications in Petroleum Industry>

UNIT 3< drinking water and waste water treatment > 8_ Hrs.

<Waste Water Treatment: Biodiesel waste water treatment; Real industrial affluent; Refinery effluent and waste water treatment; organic pollutants; hybrid approaches; Dye reduction; Industrial examples and novel approaches.

Drinking Water production: microorgamism destruction, Standards;>

UNIT 4<Other Industrial Applications> 08_ Hrs.

< Food and Dairy Technology: Rehydration of high protein milk powder; improvement of rheological and functional properties of milk powder; Food preservation; Microbial Cell disruption; Low pressure homogenization tomato juice etc.

Manufacturing: hybrid abrasive-cavitation methods for machining; ultrasonic melt processing; internal surface modification in additive manufacturing; spray coating; cavitation peening; nano-Particles.

Miscellaneous: Bio-medical applications, microfluidics, heat transfer enhancement, microchannels.>

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - <Define the fundamental terminologies used in cavitation Technology >

CO2 - <Understand the construction and working of devices used in CT>

CO3 - <Apply the CT for industrial effluents, drinking water and waste water management>

CO4 - <Identify the CT in various food and dairy technology applications>

CO5 - <Compile the information regarding miscellaneous applications of CT.>

CO6 - <Analyse and compare the conventional methods with recently developed CT >

TEXT/REFERENCE BOOKS

1. <Collection of research papers for the last five years.>
2. <Notes prepared by the faculty

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Unit 1/Question: < Two Question each with subsections(with internal choice)> <20> Marks

Unit 2/Question: < Two Question each with subsections(with internal choice)> <20> Marks

Unit 3/Question: <Two Question each with subsections(with internal choice)> <30> Marks

Unit 4/Question: < Two Question each with subsections(with internal choice)> <30> Marks

COURSE STRUCTURE FOR M.TECH. MECHANICAL SECOND YEAR Sem III (Thermal Engineering)

w.e.f 2020-21

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	20MT611	Seminar				5		40	60	--			100
2	20MT612	Project				14		40	60	--			100
3	20MT613	Industrial Training											PP/NP
		Total				**19**		**80**	**120**				**200**

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

LW = Laboratory work; LE = Laboratory Exam

20MT611					Seminar					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	4	2	04	-	-	-	-	-	50

COURSE OBJECTIVES

- Students can gain skills of group interaction, skills of integrative discussion, critical evaluation and exploring and mining a text through seminar.
- Students can develop the technical writing skill

Seminar

Each student must present any technical topic for 15 mins followed by an evaluation by a teacher for 10 minutes using evaluation criteria. All other students must attend and can give suggestions. Each student must give minimum two presentations per semester.

Technical writing

1	Definitions, structure and types of reports	4 Hrs
2	Importance of references, glossary and bibliography. How to write and insert them in reports.	6 Hrs
3	Use and types of charts and illustrations in report writing	6 Hrs
4	Various report writing techniques	6 Hrs
5	Computer aided report writing practices	4 Hrs
		26 Hrs

COURSE OUTCOMES

On outcome of the course would be as follows:
CO-1: Shy or reserved students find voice.
CO-2: Students are highly motivated to research and prepare for discussion
CO-3: Group sharing provides a more in-depth understanding of the text
CO-4: Students develop the skills for report writing.
CO-5: Students learn the standard process to write a publication quality report or research article
CO-6: Familiarization of various software tools for report writing

References:

1. Malcolm Goodale, Professional Presentations, Cambridge University Press (2009)
2. MK Rampal and S L Gupta, Project report writing, Galgotia Publishing Company, New Delhi (2010)

END SEMESTER EXAMINATION PATTERN

Max. Marks: 50

Part A: Writing skill 25 marks
Part B: Presentation 25 Marks

20MT612					Project					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	0	13	-	-	-	-	50	50	100

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – **Undertake** problem identification, formulation and solution by considering ethical responsibility

CO2 – **Demonstrate** a sound technical knowledge of their selected project topic and function as a member of a team in the solution of engineering problems

CO3 – **Formulate** and develop a hardware/software based prototype model

CO4 – **Achieve** skill to write technical documents and deliver oral presentation before an evaluation committee which in turn shall develop the communication skills

CO5 – **Identify** and **apply** appropriate steps to solve problems they have met during implementation of their project

CO6 – **Design** engineering solutions to complex problems utilizing as system approach

COURSE STRUCTURE FOR M.TECH. MECHANICAL SECOND YEAR Sem IV (Thermal Engineering) w.e.f 2020-21

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	20MT621	Seminar				5		40	60	--			100
2	20MT622	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

20MT621					Seminar					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
0	**0**	**4**	**2**	**04**	**-**	**-**	**-**	**-**	**-**	**50**

COURSE OBJECTIVES

- Students can gain skills of group interaction, skills of integrative discussion, critical evaluation and exploring and mining a text through seminar.
- Students can develop the technical writing skill

Seminar

Each student must present any technical topic for 15 mins followed by an evaluation by a teacher for 10 minutes using evaluation criteria. All other students must attend and can give suggestions. Each student must give minimum two presentations per semester.

Technical writing

1	Definitions, structure and types of reports	4 Hrs
2	Importance of references, glossary and bibliography. How to write and insert them in reports.	6 Hrs
3	Use and types of charts and illustrations in report writing	6 Hrs
4	Various report writing techniques	6 Hrs
5	Computer aided report writing practices	4 Hrs
		26 Hrs

COURSE OUTCOMES

On outcome of the course would be as follows:
CO1: Shy or reserved students find voice.
CO2: Students are highly motivated to research and prepare for discussion
CO3: Group sharing provides a more in-depth understanding of the text
CO4: Students develop the skills for report writing.
CO5: Students learn the standard process to write a publication quality report or research article
CO6: Familiarization of various software tools for report writing

References:

3. Malcolm Goodale, Professional Presentations, Cambridge University Press (2009)
4. MK Rampal and S L Gupta, Project report writing, Galgotia Publishing Company, New Delhi (2010)

END SEMESTER EXAMINATION PATTERN

Max. Marks: 50

Part A: Writing skill 25 marks
Part B: Presentation 25 Marks

20MT622					Project					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
0	**0**	**0**	**13**	**-**	**-**	**-**	**-**	**50**	**50**	**100**

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – **Undertake** problem identification, formulation and solution by considering ethical responsibility

CO2 – **Demonstrate** a sound technical knowledge of their selected project topic and function as a member of a team in the solution of engineering problems

CO3 – **Formulate** and develop a hardware/software based prototype model

CO4 – **Achieve** skill to write technical documents and deliver oral presentation before an evaluation committee which in turn shall develop the communication skills

CO5 – **Identify** and **apply** appropriate steps to solve problems they have met during implementation of their project

CO6 – **Design** engineering solutions to complex problems utilizing as system approach