UNIVERSITY INSTITUTE OF ENGINEERING AND TECHNOLOGY

(A constituent Autonomous Institute and Recognized by UGC under Section 12(B) and 2(f))

KURUKSHETRA UNIVERSITY, KURUKSHETRA

Established by the state Legislature Act XII of 1956

('A+' Grade, NAAC Accredited)

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING (CREDIT BASED)

(With specialization in Thermal Engineering)

Semester-I w.e.f. 2020-22 batch onwards

S. No.	Course No.	Course Name	L:T:P	Hours/ Week	Credits	Examination Schedule (Marks)				Duration of Exam (Hrs.)
						Major Test	Minor Test	Practical	Total	
1	MTTE-101	Advanced Fluid Dynamics	3:0:0	3	3	60	40	-	100	3
2	MTTE-103	Advanced Heat Transfer	3:0:0	3	3	60	40	-	100	3
3		[1]Programme Elective - I	3:0:0	3	3	60	40	-	100	3
4		[2]Programme Elective - II	3:0:0	3	3	60	40	-	100	3
5	MTRM-111	Research Methodology and IPR	2:0:0	2	2	60	40	-	100	3
6	MTTE-117	Advanced Heat Transfer Lab	0:0:4	4	2	-	40	60	100	3
7	MTTE-119	Refrigeration and Cryogenics Lab	0:0:4	4	2	-	40	60	100	3
8		*Audit Course –I	2:0:0	2	-	-	100*	-	100*	3
		Total		**24**	**18**	**300**	**280**	**120**	**700**	

[1]LIST OF PROGRAMME ELECTIVE – I (Thermal Engg.)			[2]LIST OF PROGRAMME ELECTIVE – II (Thermal Engg.)		
1.	MTTE-105	Advanced Thermodynamics	1.	MTTE-111	Refrigeration and Cryogenics
2.	MTTE-107	Design of Thermal Systems	2.	MTTE-113	Air Conditioning System Design
3.	MTTE-109	Energy Conservation and Management	3.	MTTE-115	Gas Turbines
***LIST OF AUDIT COURSES – I (Thermal Engg.)**					
1.	MTAD-101	English for Research Paper Writing	3.	MTAD-105	Sanskrit for Technical Knowledge
2.	MTAD-103	Disaster Management	4.	MTAD-107	Value Education

*Audit Courses I is a mandatory course which will be non-credit subject and student has to get passing marks in order to qualify the semester. However, the marks will not be added in the total marks.

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING (CREDIT BASED)
(With specialization in Thermal Engineering)
Semester-II w.e.f. 2020-22 batch onwards

S. No.	Course No.	Course Name	L:T:P	Hours/ Week	Credits	Examination Schedule (Marks)				Duration of Exam (Hrs.)
						Major Test	Minor Test	Practical	Total	
1	MTTE-102	Advanced Internal Combustion Engines	3:0:0	3	3	60	40	-	100	3
2	MTTE-104	Steam Engineering	3:0:0	3	3	60	40	-	100	3
3		[3]Programme Elective - III	3:0:0	3	3	60	40	-	100	3
4		[4]Programme Elective - IV	3:0:0	3	3	60	40	-	100	3
5	MTTE-118	Advanced Internal Combustion Engines Lab	0:0:4	4	2	-	40	60	100	3
6	MTTE-120	Computational Fluid Dynamics Lab	0:0:4	4	2	-	40	60	100	3
7	MTTE-122	Mini Project	0:0:4	4	2	-	100	-	100	3
8		*Audit Course -II	2:0:0	2	-	-	100*		100*	3
		Total		**26**	**18**	**240**	**340**	**120**	**700**	

[3]LIST OF PROGRAMME ELECTIVE – III (Thermal Engg.)			**[4]LIST OF PROGRAMME ELECTIVE – IV (Thermal Engg.)**		
1.	MTTE-106	Design of Solar and Wind Systems	1.	MTTE-112	Computational Fluid Dynamics
2.	MTTE-108	Nuclear Engineering	2.	MTTE-114	Design of Heat Transfer Equipments
3.	MTTE-110	Convective Heat Transfer	3.	MTTE-116	Compressible Flow Machines

***LIST OF AUDIT COURSES – II (Thermal Engg.)**					
1.	MTAD-202	Constitution of India	3.	MTAD-206	Stress Management by Yoga
2.	MTAD-204	Pedagogy Studies	4.	MTAD-208	Personality Development through Life Enlightenment Skills

*Audit Course-II is a mandatory course which will be non-credit subject and student has to get passing marks in order to qualify the semester. However, the marks will not be added in the total marks.

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING (CREDIT BASED)
(With specialization in Thermal Engineering)
Semester-III w.e.f. 2020-22 batch onwards

S. No.	Course No.	Course Name	L:T:P	Hours/Week	Credits	Examination Schedule (Marks)				Duration of Exam (Hrs)
						Major Test	Minor Test	Practical	Total	
1		[5]Programme Elective-V	3:0:0	3	3	60	40	-	100	3
2		[6]Open Elective	3:0:0	3	3	60	40	-	100	3
3	MTTE-207	Dissertation Phase - I	0:0:20	20	10	-	100	-	100	-
		Total		**26**	**16**	**120**	**180**	**-**	**300**	

[5]LIST OF PROGRAMME ELECTIVE – V (Thermal Engg.)		
1.	MTTE-201	Advanced Computational Fluid Dynamics
2.	MTTE-203	Finite Element Methods
3.	MTTE-205	Thermal Modeling and Analysis

[6]LIST OF OPEN ELECTIVES (Thermal Engg.)					
1.	MTOE-309	Business Analytics	4.	MTOE-315	Cost Management of Engineering Projects
2.	MTOE-311	Industrial Safety	5.	MTOE-317	Composite Materials
3.	MTOE-313	Operations Research	6.	MTOE-319	Waste to Energy

Semester-IV w.e.f. 2020-22 batch onwards

S. No.	Course No.	Course Name	L:T:P	Hours/Week	Credits	Examination Schedule (Marks)				Duration of Exam (Hrs)
						Major Test	Minor Test	Practical	Total	
1	MTTE-202	Dissertation Phase - II	0:0:32	32	16	-	100	200	300	-
		Total		**32**	**16**	**-**	**100**	**200**	**300**	

INSTRUCTIONS FOR PAPER SETTER

1. The question paper is to be attempted in **THREE Hours**.
2. Maximum Marks for the paper are **60.**
3. The syllabus for the course is divided into **FOUR units.**
4. The paper will have a total of **NINE questions.**
5. **Question No. 1,** which is compulsory, shall be OBJECTIVE Type **and will have content from the entire syllabus (all Four Units).**

   Q. No. 2 & 3 from Unit I

   Q. No. 4 & 5 from Unit II

   Q. No. 6 & 7 from Unit III

   Q. No. 8 & 9 from Unit IV
6. All questions will have equal **weightage of 12 marks.**
7. The candidate will attempt a total of **FIVE questions**, each of 12 marks. Q. No. 1 is compulsory. The candidate shall attempt remaining **four** questions by selecting **only one question from each unit.**
8. A question may have any number of sections labeled as 1(a), 1(b), 1(c), 1(d), ---- 2(a), 2(b),-- A section may further have any number of subsections labeled as (i), (ii), (iii),------.
9. **SPECIAL INSRUCTIONS FOR Q. No. 1 ONLY**

   Question No. 1, which is compulsory, shall be OBJECTIVE/ short answer type **and will have content from the entire syllabus (all Four Units).**

   Emphasis is to be given on the basic concepts, analytical reasoning and understanding of the various topics in the subject. This question may have a number of parts and/or subparts. The short questions could be combination of following types:

i. Multiple Choice
ii. Yes/ No choice
iii. Fill in Blanks type
iv. Short numerical computations
v. Definitions
vi. Matching of Tables

The above mentioned question types is **only a Guideline**. Examiner could set the question as per the nature of the subject.

First Semester

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-I

MTTE-101	ADVANCED FLUID DYNAMICS						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
3	-	-	3	60	40	100	3
Objective	To understand fluid flow problems & regimes, governing parameters, industrial applications, laminar, turbulent & compressible flows, experiments in the field of fluid mechanics.						
Course Outcomes							
CO1	Students will be able to understand the fluid flow problems along with range of governing parameters.						
CO2	Students will be able to understand the flow patterns and ability to differentiate between various flow regimes and its effects & take up related problems of industrial base.						
CO3	Students will be able to create an understanding about turbulent & compressible flows.						
CO4	Students will be able to understand the devise the experiments in the field of fluid mechanics.						

UNIT-I

Introduction: Review of basic concepts of fluid mechanics & related terminology; Lagrangian and Eulerian approach; Introduction to advanced fluid dynamics.

Equations of Fluid Flow: Reynold's transport theorem; application of RTT to establish continuity, momentum and energy equations; Integral & differential form of Euler's equation & Bernoulli's equation; Navier Stokes equation.

Ideal flow: Fluid flow kinematics; potential flow; source; sink; uniform flow around a source, sink and vortex; doublet; Rankine oval; flow around uniform cylinder with and without circulation; pressure distribution on the surface of Rankine half body and on cylinder with and without rotation; Magnus effect; D'Alembert's paradox, problems.

UNIT-II

Exact solution of N-S equations: Navier Stokes equation, relation between shear stress and pressure gradient; plane Poiseuille and Couette flow; Hagen- Poiseuille flow through circular pipe; elements of hydrodynamic theory of lubrication; flow with very low Reynold's numbers: Stokes flow around a sphere. problems.

Laminar Boundary layer flows: Elements of two-dimensional boundary layer theory; boundary layer thickness, displacement thickness, momentum thickness and energy thickness; Prandtl Boundary layer equation; Blasius solution for boundary layer on a flat plate; Von-Karman Integral Method; Karman-Pohlhausen integral method for obtaining approximate solutions; boundary layer separation & control. problems.

UNIT-III

Turbulent Flow: Characteristics of turbulent flow, laminar-turbulent transition, turbulent boundary layer theory and equation; effects of turbulence; classification of turbulence; intensity and scale of turbulence: time mean motion and fluctuations, Reynold's equations of turbulence; turbulence modelling. problems.

Compressible Flow: Introduction, basic thermodynamic relations; wave propagation & speed of sound: Mach number, Mach Cone, Mach Angle and Mach Line; Basic equations for one dimensional compressible flow: Continuity, momentum & energy equations; isentropic flow relations; compressibility correction factor; steady flow adiabatic index, critical & sonic conditions; effect of variable flow area, converging, diverging and converging-diverging nozzles and diffusers. problems.

UNIT-IV

Experimental Techniques: Role of experiments in fluid mechanics, sources of error in experiments, sources of error in measurement, data analysis: classification of data, analysis of random signals, fourier transform technique, probability density function approach.

Mechanical Measurement Techniques: Introduction, probes and transducers: hot wire anemometry; single & double wire measurement; laser doppler velocimetry: light sources & LDV; *Particle Image Velocimetry*: introduction, seeding arrangement for PIV, particle dynamics, generating a light sheet, synchronizer.

Reference/Text Books:

1. Muralidhar and Biswas, “Advanced Engineering Fluid Mechanics”, Alpha Science International, 2005.
2. Irwin Shames, “Mechanics of Fluids”, McGraw Hill, 2003
3. R.W., McDonald A.T., “Introduction to Fluid Mechanics”, John Wiley and Sons Inc, 1985
4. Pijush K. Kundu, Ira M Kohen and David R. Dawaling, “Fluid Mechanics”, Fifth Edition, 2005
5. I.G. Currie, “Fundamentals of Mechanics of Fluid”, McGraw-Hill.
6. Yuan, “Foundation of Fluid Mechanics”, Prentice Hall.
7. R.W. Fox, P.J. Pritchard & A.T. McDonald, “Introduction to Fluid Mechanics”, Wiley India.
8. S.K. Som and G. Biswas, “Introduction to Fluid Mechanics and Fluid Machines”, Tata McGraw.
9. Gupta and Gupta, “Fluid Mechanics and its applications”, Willey Easter.
10. Dr. D.S. Kumar, ‘Fluid Mechanics and Fluid Power Engineering’, Katson Books.

Note: The paper will have a total of NINE questions. Question No. 1, which is compulsory, shall be Short Answer or Objective Type and have contents from the entire syllabus (all Four Units).

All questions will carry equal **weightage of 12 marks**. The student will attempt a total of **FIVE questions,** each of 12 marks. Q. No. 1 is compulsory. The student shall attempt remaining four questions by selecting **only one question from each unit**

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-I

MTTE-103	**ADVANCED HEAT TRANSFER**						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**-**	**-**	**3**	**60**	**40**	**100**	**3**
Objective	**To understand the subject of Heat Transfer in detail with capability to solve Industrial Problems. This will also create the base and interest among the students to carry out the Future Research.**						
Course Outcomes							
CO 1	**The students will be able to formulate and analyze a heat transfer problem involving any of the three modes of heat transfer.**						
CO 2	**The students will be able to obtain exact solutions for the temperature variation using analytical methods where possible or employ approximate methods or empirical correlations to evaluate the rate of heat transfer**						
CO 3	**The students will be able to design devices such as heat exchangers and also estimate the insulation needed to reduce heat losses where necessary.**						

UNIT-I

Conductive Heat Transfer: Review of the basic laws of conduction, convection and radiation. general heat conduction equation in different co-ordinates, one dimensional steady state conduction with variable thermal conductivity and with internal distributed heat sources, critical radius of insulation, extended surfaces review, generalized equation for fins, tapered fins, design considerations.

Two and three dimensional steady-state conduction, method of separation of variables, graphical method, relaxation technique.

Transient heat conduction: lumped capacitance analysis, plane wall with convection, radial systems with convection, semi-infinite solid, periodic heating, solutions using Heisler's charts.

UNIT-II

Convective Heat Transfer: Introduction to convection boundary layers, local and average convection coefficients, laminar and turbulent flow, boundary layer equations, boundary layer similarity, boundary layer analogies – heat and mass transfer analogy, Reynold's and Colburn analogies.

Forced convection: External forced convection - empirical method, flat plate in parallel flow, cylinder in cross flow, flow over a sphere; internal forced convection – hydrodynamic and thermal considerations, energy balance, laminar flow in circular tubes, convection correlations.

Natural Convection: Physical considerations, governing equations, laminar free convection on vertical surface, empirical correlations, free convection within parallel plate channels, empirical correlations, combined free and forced convection.

UNIT-III

Boiling and Condensation: Dimensionless parameters in boiling and condensation, boiling modes, pool boiling, correlations, forced convection boiling, physical mechanism of condensation, laminar and turbulent film condensation, film condensation in tubes, dropwise condensation. Special topics: transpiration cooling, ablation heat transfer, fluidized bed combustion.

Heat Exchangers: Basic design methodologies – LMTD and effectiveness NTU methods, overall heat transfer coefficient, fouling of heat exchangers, classification of heat exchangers according to constructional features: tubular, plate type, extended surface heat exchanger, compact heat exchangers, plate and heat pipe type heat exchangers, heat transfer enhancement - passive and active techniques.

UNIT-IV

Radiative Heat Transfer: Fundamental concepts, radiation intensity, irradiation, radiosity, black body radiation, basic laws of radiation, emission from real surfaces, absorption, reflection and transmission by real surfaces, Kirchoff's law, gray surface, radiative heat exchange between two or more surfaces, view factor, radiation exchange between opaque, diffuse, gray surface in an enclosure; net radiation exchange at a surface, radiation exchange between surfaces, blackbody radiation exchange, two-surface enclosure, radiation shields, multimode heat transfer, radiation of gases and vapour.

Mass Transfer: Physical origins and rate equations, mixture composition, Fick's law of diffusion, mass transfer in stationary media, steady state diffusion through a plane membrane, equimolal diffusion, diffusion of water vapours through air, mass transfer coefficient, convective mass transfer, correlations.

Reference/Text Books:

1. Incropera, Dewitt, Bergmann and Levine, "Fundamentals of Heat and Mass Transfer", Wiley India, 2006.
2. J.P. Holman, "Heat Transfer", McGraw Hill, 1996.
3. Y.V.C. Rao, "Heat and Mass Transfer", Universities Press, 2001.
4. D.S. Kumar, "Heat and Mass Transfer", Katson Publication, 2013.
5. Kreith and Bohn, "Principles of Heat Transfer", Cengage Learning, Inc. 7th Edition, 2009.
6. N.H. Afgan and Schliinder, "Heat Exchangers Design and Theory", McGraw Hill.

Note: The paper will have a total of NINE questions. Question No. 1, which is compulsory, shall be Short Answer or Objective Type and have contents from the entire syllabus (all Four Units).

All questions will carry equal **weightage of 12 marks**. The student will attempt a total of **FIVE questions,** each of 12 marks. Q. No. 1 is compulsory. The student shall attempt remaining four questions by selecting **only one question from each unit**

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
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Semester-I

MTRM-111	RESEARCH METHODOLOGY AND IPR						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
2	-	-	2	60	40	100	3
Objective	To familiarize the students with the research problem formulation and approach and understand the importance of Intellectual property rights.						
Course Outcomes							
CO 1	Student will be able to understand research problem formulation.						
CO 2	Student will be able to analyze research related information and follow research ethics.						
CO 3	Student will be able to understand the Patents, Designs, Trade and Copyright and able to apply the knowledge for patent.						
CO 4	Student will be able to understand the concept of Patent Rights, Licensing and transfer of technology and able to apply the knowledge in new Developments in IPR.						

Unit-I

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

Unit-II

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

Unit-III

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

Unit-IV

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and Institutions.

Reference/Text Books:

1. Stuart Melville and Wayne Goddard, "Research methodology: An introduction for science & engineering students" Kenwyn, South Africa : Juta & Co. Ltd., 1996
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction" Juta Academic; 2nd edition (April 28, 2004)
3. Ranjit Kumar, "Research Methodology: A Step by Step Guide for beginners" SAGE Publications Ltd; Fourth edition (14 January 2014)
4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd, 2007.
5. Mayall, "Industrial Design", McGraw Hill, 1992.

6. Niebel, "Product Design", McGraw Hill, 1974.
7. Asimov, "Introduction to Design", Prentice Hall, 1962.
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age", Aspen Publishers; Revised edition (July 25, 2007)
9. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

Note: The paper will have a total of NINE questions. Question No. 1, which is compulsory, shall be Short Answer or Objective Type and have contents from the entire syllabus (all Four Units).

All questions will carry equal **weightage of 12 marks**. The student will attempt a total of **FIVE questions,** each of 12 marks. Q. No. 1 is compulsory. The student shall attempt remaining four questions by selecting **only one question from each unit**

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
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Semester-I

MTTE-117	ADVANCED HEAT TRANSFER LAB							
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Practical Marks	Total	Time (Hrs.)
-	-	4	2	-	40	60	100	3
Objective	To design and conduct experiments, and acquire, analyze and interpret data.							
Course Outcomes								
CO 1	Students will understand the heat pipe and demonstrate its super thermal conductivity.							
CO 2	Students will determine the overall heat transfer, Biot and Fourier numbers in unsteady state heat conduction.							
CO 3	Students will be able to measure the heat transfer characteristics in convective heat transfer.							
CO 4	Students will be able to analyze and determine the heat transfer characteristics for heat exchangers and understand different heat enhancement techniques.							
CO 5	Students will be able to measure the emissivity, thermal conductivity etc.							

List of Experiments

1. To determine the emissivity of a test plate.
2. To demonstrate the super thermal conductivity of heat pipe.
3. To determine the natural convective heat transfer coefficient along a vertical test tube.
4. To find out heat transfer coefficient of drop wise and film wise condensation at various flow rates of water.
5. To study different types of heat enhancement techniques.
6. To determine the Biot number, Fourier number and heat transfer coefficient for unsteady heat transfer.
7. To find out the overall heat transfer coefficient and LMTD of a plate type heat exchanger.
8. To calculate heat transfer coefficient of the fluidized bed.
9. To find out the overall heat transfer coefficient and LMTD of a finned tube heat exchanger.
10. To determine the LMTD, overall heat transfer coefficient and effectiveness of evaporative heat exchanger.
11. To find out the heat flux and temperature difference between metal & liquid in a two phase transfer unit.
12. To determine the overall heat transfer co-efficient under unsteady state conditions at different temperatures and heat transfer coefficient at boiling point.
13. To determine the thermal conductivity of different fluids.

Note: Total eight experiments are to be performed selecting at least six from the above list.

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
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Semester-I

MTTE-119	REFRIGERATION AND CRYOGENICS LAB							
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Practical Marks	Total	Time (Hrs.)
-	-	4	2	-	40	60	100	3
Objective	To make students understand the applications of refrigeration and cryogenics.							
Course Outcomes								
CO 1	Students will understand about the basics and working of refrigeration and cryogenics systems.							
CO 2	Students will be able to identify the different cycle of operation in refrigeration.							
CO 3	Students will know the working principle to achieve very low temperature and its importance in air-conditioning.							
CO 4	Student will learn about the various working and design of different types of refrigeration systems.							

List of Experiments

1. To study and perform experiment on compound vapour compression Refrigeration Cycle.
2. To study and perform experiment on Solar Air-conditioner based on vapour absorption cycle.
3. To study and perform experiments on multi-load systems.
4. To study and perform experiment on vapour absorption apparatus.
5. To find the performance parameter of cooling tower.
6. To study various components in room air conditioner.
7. To find performance of a refrigeration test rig system by using different expansion devices.
8. To study and perform experiments on cascade system.
9. To study and perform experiments on dry ice machine.
10. To study and perform experiments on gas liquefaction system.
11. To study and perform experiments on desiccant evaporative cooling system.

Note: Total eight experiments are to be performed selecting at least six from the above list.

Program Elective - I

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
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Semester-I

MTTE-105	ADVANCED THERMODYNAMICS						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
3	-	-	3	60	40	100	3
Objective	To acquaint the students with fundamentals of advanced thermodynamics.						
Course Outcomes							
CO 1	Student will get knowledge of exergy, basic laws governing energy conversion in multicomponent systems and application of chemical thermodynamics.						
CO 2	Student will be aware about advanced concepts in thermodynamics with emphasis on thermodynamic relations, equilibrium and stability of multiphase multi-component systems.						
CO 3	Students will be able to present theoretical, semi-theoretical and empirical models for the prediction of thermodynamic properties.						
CO 4	Student will acquire the confidence in analyze the motion of combusting and non-combusting fluids whilst accounting for variable specific heats, non-ideal gas properties, chemical non-equilibrium and compressibility.						

UNIT–I

Basic Concepts: Thermodynamics, Zeroth law of thermodynamics, first law of thermodynamics, limitations of first law, corollaries, concept of internal energy transient flow analysis, second law of thermodynamics, corollaries, concept of entropy, availability and unavailability, availability function of the closed system, availability of steady flow system irreversibility.

Thermodynamic Relations: Introduction, thermodynamic potentials, Maxwell relations, specific heat relations, Mayer's relation, general relations for du, dh, ds.

UNIT–II

Perfect Gases: P.V.T. surface, equations of state, real gas behavior, Vander Waal's equation, generalized compressibility factor, energy properties of real gases, vapour pressure, Clausius–Clapeyron equation, throttling, Joule–Thompson coefficient.

Non-reactive Mixture of perfect Gases: governing laws – evaluation of properties, psychrometric mixture properties and psychrometric chart – air conditioning processes – real gas mixture.

UNIT–III

Reactive Gas Mixtures: Combustion: introduction, combustion reactions, enthalpy of formation, entropy of formation, adiabatic flame temperature, first and second law analysis of reacting systems.

Thermodynamic cycles: Vapor power cycles, second law analysis of vapor power cycles, cogeneration, binary vapor cycles, and combined gas vapor power cycles. gas power cycles: ideal jet propulsion cycles- second law analysis of gas power cycles.

UNIT–IV

Statistical thermodynamics: Statistical interpretations of first and second law and entropy, Nernst heat theorem.

Kinetic theory of gases: Molecular model, Clausius equation of state, Vander waals equation of state, Maxwell Boltzmann velocity distribution. Dimensional analysis and similitude. Incompressible viscous flow, simplification of Navier stokes equation for steady incompressible flows.

Reference/Text books:

1. Cengel, "Thermodynamics", Tata McGraw Hill Co., New Delhi, 1980.
2. Howell and Dedcius, "Fundamentals of Engineering Thermodynamics", McGraw Hill Inc., U.S.A.
3. Van Wylen & Sonntag, "Thermodynamics", John Wiley and Sons Inc., U.S.A.
4. Jones and Hawkings, "Engineering Thermodynamics", John Wiley and Sons Inc., U.S.A, 2004.
5. Holman, "Thermodynamics", McGraw Hill Inc., New York, 2002.
6. Faires V.M. and Simmag, "Thermodynamics", Macmillan Publishing Co. Inc., U.S.A.
7. Rao Y.V.C., "Postulational and Statistical Thermodynamics", Allied Publishers Inc, 1994.

Note: The paper will have a total of NINE questions. Question No. 1, which is compulsory, shall be Short Answer or Objective Type and have contents from the entire syllabus (all Four Units).

All questions will carry equal **weightage of 12 marks**. The student will attempt a total of **FIVE questions,** each of 12 marks. Q. No. 1 is compulsory. The student shall attempt remaining four questions by selecting **only one question from each unit**

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-I

MTTE-107	DESIGN OF THERMAL SYSTEMS						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
3	-	-	3	60	40	100	3
Objective	To provide the mathematical modelling and analysis for designing the thermal systems. Also students will be able to understand the dynamic behaviour of thermal systems.						
Course Outcomes							
CO 1	Students will be able to understand the basic concepts for designing the thermal systems. Also to discuss mathematical modelling of thermal systems using computer programmes.						
CO 2	Students will be able to equip for modelling the thermal systems like heat exchangers, evaporators, condensers etc. Also to understand their solution procedures.						
CO 3	Students will able to understand the concepts of optimization and its various methods for solving the thermal problems. Also to study geometric, linear and dynamic programming.						
CO 4	Students will learn the dynamic behaviour of thermal systems. Also to learn stability analysis and non-linearity.						
CO 5	Students will able to understand the basic concepts for designing the thermal systems. Also to discuss mathematical modelling of thermal systems using computer programmes.						

UNIT-I

Design of Thermal System: Modeling of thermal system, types of models, mathematical modeling, curve fitting, linear algebraic systems, numerical model for a system, system simulation, methods of numerical simulation.

UNIT-II

Mathematical Modeling: Acceptable design of thermal system, initial design, design strategies, design of system for different application area, additional consideration for a practical system,

UNIT-III

Modeling Thermal Equipments: Economic consideration, calculation of interest, worth of money as a function of time, series of payments, raising capital, taxes, economic factor in design consideration

UNIT-IV

Systems Optimization: Problem formulation for optimization, optimization methods, optimization of thermal systems, practical aspect in optimal design, Lagrange multipliers, optimization of constrained and unconstrained problems, applicability to thermal systems, search method, single variable problem, multi-variable constrained optimization, examples of thermal systems, geometric, linear and dynamic programming, knowledge–based design and additional considerations.

Reference/Text Books:

1.Hodge, B.K. and Taylor, R. P., "Analysis and Design of Energy Systems", Prentice Hall (1999).
2.Bejan, A., Tsatsaronis, G. and Michel, M., "Thermal Design and Optimization", John Wiley and Sons (199
3.Jaluria, Y., "Design and Optimization of Thermal Systems", CRC Press (2008).
4.Ishigai, S., "Steam Power Engineering Thermal and Hydraulic Design Principle", Cambridge University

Note: The paper will have a total of NINE questions. Question No. 1, which is compulsory, shall be Short Answer or Objective Type and have contents from the entire syllabus (all Four Units).

All questions will carry equal **weightage of 12 marks**. The student will attempt a total of **FIVE questions,** each of 12 marks. Q. No. 1 is compulsory. The student shall attempt remaining four questions by selecting **only one question from each unit**

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-I

MTTE-109	ENERGY CONSERVATION AND MANAGEMENT						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
3	-	-	3	60	40	100	3
Objective	To impart knowledge about Energy utilization, categorization, site selection & important aspects of Solar, wind, hydro, ocean, wave, tidal, geothermal, bio-mass & energy management.						
Course Outcomes							
CO 1	Students will be able to inculcate the methods of utilization, types, site selection & surveys etc. of Solar, Wind, Chemical, MHD sources of energy.						
CO 2	Students will have the understanding of methods of utilization, types, site selection & surveys etc. of Energy from Oceans and Hydropower.						
CO 3	Students will be able to acquire knowledge and comprehend various methods of utilization, types, site selection & surveys etc. of Bio-energy and Geothermal energy.						
CO 4	Students will be able to gain knowledge of generation of scenarios of energy consumption and predict the future trend. The student will be able to suggest and plan energy conservation solutions.						

UNIT-I

Solar Energy: Introduction; associated terminology; direct solar energy utilization; solar thermal applications.

Chemical Energy Sources: Introduction; fuel cells: design, principle, operation, classification, types.

MHD Systems: Introduction; principle of MHD power generation, MHD systems.

Wind energy: Introduction; basic principles of wind energy conversion; nature of wind; power in the wind; thrust on blades; wind energy conversion; design of windmills; wind data and energy estimation; site selection considerations; basic components of WECS.

UNIT-II

Biomass and bio-fuels: Energy plantation; biogas generation; types of biogas plants; applications of biogas; waste energy generation; biodiesel.

Energy conservation in Industries: Cogeneration; combined heating and power systems; relevant international standards and laws.

UNIT-III

Oceanic Energy: Energy from waves; wave energy conversion devices; advantages and disadvantages of wave energy; basic principles of tidal energy; tidal power generation systems; estimation of energy and power; advantages and limitations of tidal power generation; ocean thermal energy conversion (OTEC); methods of ocean thermal electric power generation.

Hydro power: Classification of small hydro power (SHP) stations; description of basic civil works design considerations; turbines and generators for SHP; advantages and limitations.

UNIT-IV

Energy Conservation & Management: Energy management; energy management planning; Pareto's model; application of Pareto's model for energy management; obtaining management support; establishing energy data base; energy economics.

Energy Audit: Conducting energy audit; Identifying, evaluating and implementing feasible energy conservation opportunities; energy audit report; monitoring, evaluating and following up energy saving measures/projects.

Reference/Text Books:

1. L.C. Witte, P.S. Schmidt, D.R. Brown, "Industrial Energy Management and Utilization", Hemispherical Publication, 1988.

2. Paul W. O'Callaghan, "Design and Management for Energy Conservation" Pergamon Pr; 1st edition (December 1, 1981)

3. D.A. Reeg, "Industrial Energy Conservation", Pergamon Press, 1980.

4. T.L. Boyen, "Thermal Energy Recovery" Wiley, 1980.

5. L.J. Nagrath, "Systems Modeling and Analysis", Tata McGraw Hill, 1982.

6. W.C. Turner, "Energy Management Handbook ", Wiley, New York, 1982.

7. I.G.C. Dryden, "The Efficient Use of Energy ", Butterworth, London, 1982.

8. Godfrey Boyle (Edited by), "Renewable energy – power for sustainable future", Oxford University Press in association with the Open University, 1996.

9. S.A. Abbasi and Naseema Abbasi, "Renewable energy sources and their environmental impact" Prentice-Hall of India, 2001.

10. G.D. Rai, "Non-conventional sources of energy" Khanna Publishers, 2000.

11. G.D. Rai, "Solar energy utilization" Khanna Publishers, 2000.

12. S.L.Sah, "Renewable and novel energy sources", M. I. Publications, 1995.

13. S.Rao and B.B. Parulekar, "Energy Technology", Khanna Publishers, 1999.

Note: The paper will have a total of NINE questions. Question No. 1, which is compulsory, shall be Short Answer or Objective Type and have contents from the entire syllabus (all Four Units).

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Program Elective - II

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-I

MTTE-111	REFRIGERATION AND CRYOGENICS						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
3	-	-	3	60	40	100	3
Objective	To acquaint the students with fundamentals of refrigeration and cryogenics.						
Course Outcomes							
CO 1	Students will learn the basics of refrigeration and cryogenics and its application area.						
CO 2	Students will be able to design the refrigeration systems for domestic and industrial applications like cold storages.						
CO 3	Students will learn about refrigerants and their uses for different refrigeration applications and related environment issues.						
CO 4	Students will able to design the heat based systems and the systems for the liquefaction of gases.						

Unit-I

Vapour compression system: Vapour compression refrigeration, Ewing's construction, standard rating cycle and effect on operating conditions, actual cycle, standard rating cycle for domestic refrigerator, second law efficiency.

Multi-pressure systems: Working and analysis of multi-stage compression with inter-cooling, multi-evaporator systems, cascade systems.

Unit-II

Refrigerant Compressors: Performance characteristics and capacity control of reciprocating and centrifugal compressors, screw compressor and scroll compressor,

Components of Vapor compression system: Design, selection of evaporators, condensers, control systems, motor selection.

Unit-III

Refrigerants: Introduction, designation of refrigerants, alternative refrigerants, CFC/HCFC phase-out regulations, atmospheric gases as substitute for CFC refrigerants, binary and azeotropic mixtures.

Refrigeration applications: Food preservation, cooling and heating of foods, freezing of foods, freeze drying and heat drying of foods, transport refrigeration

Unit-IV

Vapour absorption system: Introduction to vapor absorption refrigeration, common refrigerant-absorbent systems, single effect and double effect systems, new mixtures for absorption system.

Gas liquefaction systems: Linde-Hampson, Linde dual pressure, Claude cycle, properties of cryogenic liquids, super fluidity, properties of solids at cryogenic temperatures

Reference/Text Books:

1. R. J. Dossat, "Principles of Refrigeration", Pearson Education Asia, 2001.
2. C. P. Arora, "Refrigeration and Air-conditioning", Tata McGraw-Hill, 2000.
3. Stoecker & Jones, "Refrigeration and Air-conditioning", McGraw Hill Book Company, New York, 1982.
4. A. R. Trott, "Refrigeration and Air-conditioning", Butterworths, 2000.
5. J. L. Threlkeld, "Thermal Environmental Engineering", Prentice Hall, 1970.

6. R. Barron, “Cryogenic systems”, McGraw–Hill Company, New Yourk, 1985.
7. G. G. Hasseldon. “Cryogenic Fundamentals”, Academic Press.
8. Bailey, “Advanced Cryogenics”, Plenum Press, London, 1971.
9. W. F. Stoecker, “Industrial Refrigeration Handbook”, McGraw-Hill, 1998.
10. John A. Corinchock, “Technician’s Guide to Refrigeration systems”, McGrawHill.
11. P. C. Koelet, “Industrial Refrigeration: Principles, Design and Applications”, Macmillan, 1992.
12. ASHRAE HANDBOOKS (i) Fundamentals (ii) Refrigeration.
13. Graham Walker, “Miniature Refrigerators for Cryogenic Sensors and Cold Electronics”, Clarendon Press, 1989.

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All questions will carry equal **weightage of 12 marks**. The student will attempt a total of **FIVE questions,** each of 12 marks. Q. No. 1 is compulsory. The student shall attempt remaining four questions by selecting **only one question from each unit**

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-I

MTTE-113	AIR CONDITIONING SYSTEM DESIGN						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
3	-	-	3	60	40	100	3
Objective	To acquaint the students with fundamentals of heating, ventilation and air-conditioning.						
Course Outcomes							
CO 1	Student will be able to understand construction and design features of Air-conditioning system.						
CO 2	Student will be able to understand various types and its adoptability in the various environment and application areas.						
CO 3	Student will be able to understand about the indoor air quality and various health issues related to Indoor air.						
CO 4	Student will be able to design seasonal energy efficient system						

Unit-I

Air conditioning systems: The complete air-conditioning system, system selection and arrangement, HVAC components and distribution system, all-air, air-water and all-water systems, decentralized cooling and heating.

Various air-conditioning processes: Moist air and standard atmosphere, Adiabatic saturation, classic moist air processes, Space air conditioning: design conditions, off-design conditions.

Unit-II

Comfort and health-Indoor air quality: Enthalpy deviation curve, psychrometry, SHF, dehumidified air quantity, human comfort, indoor air quality.

Heat transmission in building structures: Basic heat transfer modes, tabulated overall heat-transfer coefficient.

Unit-III

Design conditions and load calculations: Space heating load: outdoor and indoor design conditions, transmission heat losses, infiltration, heat losses from air duct. solar radiation

The cooling load: Design conditions, Internal heat gain, transient conduction heat transfer, fenestration: transmitted solar radiations.

Unit-IV

Fan and Building air distribution: Fan performance and selection, fans and variable-air-volume systems, air flow in ducts and fittings, pressure drop, duct design, & blowers, performance & selection, noise control.

Reference/Text Books:

1. ASHRAE Handbook.
2. “Handbook of air-conditioning system design”, Carrier Incorporation, McGraw Hill Book Co., U.S.A, 1965.
3. Norman C. Harris, “Modern Air Conditioning”, McGraw-Hill, 1974.
4. Jones W.P., “Air Conditioning Engineering”, Edward Arnold Publishers Ltd., London, 1984.
5. Hainer R.W., “Control Systems for Heating, Ventilation and Air-Conditioning”, Van Nostrand
6. Reinhold Co., New York, 1984. 7. Arora C.P., “Refrigeration & Air Conditioning”, Tata Mc Graw Hill, 1985.
7. Manohar Prasad, “Refrigeration & Air Conditioning”, New Age Publishers.
8. Stoecker, “Refrigeration & Air Conditioning”, Mc Graw Hill, 1992.

9. Stoecker, "Design of Thermal Systems", Mc Graw Hill, 1992.
10. F. C. McQuiston, J. D Parker, J. D. Spitler "Heating, Ventilation and Air-conditioning", Wiley publications.

Note: The paper will have a total of NINE questions. Question No. 1, which is compulsory, shall be Short Answer or Objective Type and have contents from the entire syllabus (all Four Units).

All questions will carry equal **weightage of 12 marks**. The student will attempt a total of **FIVE questions,** each of 12 marks. Q. No. 1 is compulsory. The student shall attempt remaining four questions by selecting **only one question from each unit**

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-I

MTTE-115	GAS TURBINES						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
3	-	-	3	60	40	100	3
Objective	To design and analyze the performance of gas turbines and propulsion devices.						
Course Outcomes							
CO 1	Students will able to understand the ideal and real thermodynamic cycles of air-breathing engines and Industrial gas turbines						
CO 2	Students will able to understand design the blading, study the velocity triangles and estimate the performance of centrifugal and axial flow compressors.						
CO 3	Students will able to understand the combustion process and design the combustion chamber of a gas Turbine.						
CO 4	Students will able to understand design the blading, study the velocity triangles and estimate the performance of axial and radial in-flow turbines						
CO 5	Students will able to understand analyze the off-design performance and matching of the components of a gas turbine						

UNIT-I

Introduction: Classification of turbomachines, applications of gas turbines, assumptions for air-standard cycles, simple Brayton cycle, heat exchange cycle, inter-cooling and reheating cycle, comparison of various cycles.

Compressible flow: Energy and momentum equations for compressible fluid flows, various regions of flows, reference velocities, stagnation state, velocity of sound, critical states, Mach number, critical Mach number, types of waves, Mach cone, Mach angle, effect of Mach number on compressibility

UNIT-II

Real Cycles and their Analysis: Methods of accounting for component losses, isentropic and polytropic efficiencies, transmission and combustion efficiencies, comparative performance of practical cycles, combined cycles and cogeneration schemes.

Jet Propulsion Cycles and their Analysis: Criteria of performance, simple turbojet engine, simple turbofan engine, simple turboprop engine, turbo-shaft engine, thrust augmentation techniques.

Combustion System: Operational requirements, classification of combustion chambers, factors effecting combustion chamber design, the combustion process, flame stabilization, combustion chamber performance, some practical problems gas turbine emissions.

UNIT-III

Fundamentals of Rotating Machines: General fluid dynamic analysis, Euler's energy equation, components of energy transfer, impulse and reaction machines.

Centrifugal Compressors: Construction and principle of operation, elementary theory and velocity triangles, factors effecting stage pressure ratio, the diffuser, the compressibility effects, pre-rotation and slip factor, surging and choking, performance characteristics.

UNIT-IV

Flow Through Cascades: Cascade of blades, axial compressor cascades, lift and drag forces, cascade efficiency, cascade tunnel.

Axial Flow Compressors: Construction and principle of operation, elementary theory and velocity triangles, factors effecting stage pressure ratio, degree of reaction, work done factor, three dimensional flow, design process, blade design, stage performance, compressibility effects, off-design performance.
Axial and Radial Flow Turbines: Construction and operation, vortex theory, estimation of stage performance, overall turbine performance, turbine blade cooling, the radial flow turbine.
Off-Design Performance: Off-design performance of single shaft gas turbine, off-design performance of free turbine engine, off-design performance of the jet engine, methods of displacing the equilibrium running line.

Reference/Text Books:

1. Sarvana Muttoo, H.I.H., Rogers, G. F. C. and Cohen, H., "Gas Turbine Theory", 6th Edition, Pearson 2008.
2. Dixon, S.L., "Fluid Mechanics and Thermodynamics of Turbomachinery", 7th Edition, Elsevier, 2014.
3. Flack, R.D., "Fundamentals of Jet Propulsion with Applications", Cambridge University Press, 2011.
4. Ganesan, V., "Gas Turbines", 3rd Edition, Tata McGraw Hill, 2010.
5. Yahya, S. M., "Turbines, Compressors and Fans", 4th Edition, McGraw Hill.

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Audit Course - I

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-I

MTAD-101	ENGLISH FOR RESEARCH PAPER WRITING						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
2	-	-	-	-	100	100	3
Objective	To understand how to improve writing skills and level of readability and develop skills needed for writing a good quality paper.						
Course Outcomes							
CO1	Students will understand how to improve your writing skills and level of readability.						
CO2	Learn about what to write in each section.						
CO3	Understand the skills needed when writing a Title.						
CO4	Students will be able to ensure the good quality of paper at very first-time submission.						

Unit-I

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

Unit-II

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction

Unit-III

Review of the Literature, Methods, Results, Discussion, Conclusions, the Final Check. Key skills needed when writing a Title, key skills needed when writing an abstract, key skills needed when writing an Introduction, skills needed when writing a Review of the Literature.

Unit-IV

Skills needed when writing the Methods, skills needed when writing the Results, skills needed when writing the Discussion, skills needed when writing the Conclusions, Useful phrases, how to ensure paper is as good as it could possibly be the first- time submission

Reference/Text Books:

1. Goldbort R, “Writing for Science”, Yale University Press (available on Google Books)
2. Day R, “How to Write and Publish a Scientific Paper”, Cambridge University Press
3. Highman N, “Handbook of Writing for the Mathematical Sciences”, SIAM. Highman’s book.
4. Adrian Wallwork, “English for Writing Research Papers”, Springer New York Dordrecht Heidelberg London, 2011

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-I

MTAD-103	DISASTER MANAGEMENT						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
2	-	-	-	-	100	100	3
Objective	To acquaint the students with various disasters and hazards and management.						
Course Outcomes							
CO1	Learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.						
CO2	Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.						
CO3	Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.						
CO4	Critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in.						

Unit-I

Disaster: Definition, Factors and Significance; Difference between Hazard and Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

Unit-II

Repercussions of Disasters and Hazards: Economic Damage, Loss of Human and Animal Life, Destruction of Ecosystem.
Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts and Famines, Landslides and Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks and Spills, Outbreaks of Disease and Epidemics, War and Conflicts.

Unit-III

Study of Seismic Zones; Areas Prone to Floods and Droughts, Landslides and Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference to Tsunami; Post-Disaster Diseases and Epidemics.
Preparedness: Monitoring of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data From Meteorological and other Agencies, Media Reports: Governmental and Community Preparedness.

Unit-IV

Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival.
Meaning, Concept and Strategies of Disaster Mitigation, Emerging Trends in Mitigation. Structural Mitigation and Non-Structural Mitigation, Programs of Disaster Mitigation in India.

Reference/Text Books:

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company.

2. Sahni, Pardeep (Eds.)," Disaster Mitigation Experiences and Reflections", Prentice Hall of India, New Delhi.
3. Goel S. L., "Disaster Administration and Management Text and Case Studies", Deep & Deep Publication Pvt. Ltd., New Delhi.

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-I

MTAD- 105	SANSKRIT FOR TECHNICAL KNOWLEDGE						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
2	-	-	-	-	100	100	3
Objective	To understand basic Sanskrit language and Ancient Sanskrit literature related to science & technology.						
Course Outcomes							
CO1	Students will get a working knowledge in illustrious Sanskrit, the scientific language of the world.						
CO2	Learning of Sanskrit to improve brain functioning.						
CO3	Learning of Sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power.						
CO4	The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature.						

Unit-I

Alphabets in Sanskrit, Past/Present/Future Tense, Simple Sentences

Unit-II

Order, Introduction of roots, Technical information about Sanskrit Literature

Unit-III

Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics

Reference/Text Books:

1. Dr.Vishwas, “Abhyaspustakam” Samskrita-Bharti Publication, New Delhi
2. Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam “Teach Yourself Sanskrit” Prathama Deeksha-, New Delhi Publication
3. Suresh Soni, “India’s Glorious Scientific Tradition” Ocean books (P) Ltd., New Delhi.

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-I

MTAD-107	VALUE EDUCATION						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
2	-	-	-	-	100	100	3
Objective	Understand value of education and self- development, Imbibe good values in students and Let them know about the importance of character building.						
Course Outcomes							
CO1	Knowledge of self-development.						
CO2	Learn the importance of Human values.						
CO3	Developing the overall personality.						
CO4	Know about the importance of character.						

Unit-I

Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism. Moral and non- moral valuation. Standards and principles. Value judgements

Unit-II

Importance of cultivation of values. Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. Honesty, Humanity. Power of faith, National Unity. Patriotism. Love for nature, Discipline

Unit-III

Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline. Punctuality, Love and Kindness. Avoid fault Thinking. Free from anger, Dignity of labour. Universal brotherhood and religious tolerance. True friendship. Happiness Vs suffering, love for truth. Aware of self-destructive habits. Association and Cooperation. Doing best for saving nature

Unit-IV

Character and Competence –Holy books vs Blind faith. Self-management and Good health. Science of reincarnation. Equality, Nonviolence, Humility, Role of Women. All religions and same message. Mind your Mind, Self-control. Honesty, studying effectively

Reference/Text Books:

1. Chakroborty, S.K. "Values and Ethics for organizations Theory and practice", Oxford University Press, New Delhi

Second Semester

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-II

MTTE-102	ADVANCED INTERNAL COMBUSTION ENGINES						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
3	-	-	3	60	40	100	3

Objective	To enable the students to understand the modern Engine concepts, Sensor for automobiles. The course will also help the students to compare various emission norms and capability to develop capacity to identify various after treatment devices for pollution control.
Course Outcomes	
CO 1	Students will able to develop capacity to analyse and characterise the processes working behind modern Engines based on HCCI and other modern concepts on which future I.C. Engines might be built.
CO 2	Students will able to differentiate old Emission standards with latest emission norms in India and Internationally.
CO 3	Students will able to recognize, describe, predict, and analyze different after-treatment technologies need to be installed in a particular type of engine for controlling different kinds of pollutants
CO 4	Students will able to understand develop the capacity to understand basic elements of Automotive Electronic Engine control system, identify and select various sensors used for Electronic Controls of Engines.
CO 5	Students will have the capacity to compare various alternative fuels used in Engines bases on their properties, advantages and limitations.
CO 6	Students will able to test and evaluate quality of fuels as per International standards.

UNIT-I

Homogeneous Charge Compression Ignition Engines: Introduction, historical background of HCCI/CAI type combustion engines, controlled auto-ignition gasoline engines, HCCI diesel engines, principle of HCCI/CAI combustion engine, performance and emission characteristics of conventional combustion and HCCI/CAI combustion.

Combustion characteristics of CAI Engines, effects of use of exhaust gases as diluents, various approaches to CAI/HCCI operation in gasoline engines, challenges facing CAI/HCCI combustion in the gasoline engine, future directions in HCCI/CAI engines, premixed charge compression Ignition (PCCI), Reactivity-Controlled Compression Ignition (RCCI)

UNIT-II

Future Mobility Solutions of Indian Automotive Industry: Evolution of emission standards in India, BS-VI emission standards, hybrid, and electric Vehicles, challenges for transport Sector, emerging engine technologies, possible solutions for future road transport sector,

Advancements in After-Treatment Technology for Internal Combustion: engines selective catalytic reduction (SCR) de-NOx after-treatment approach, use of NOx trap after-treatment device approaches, control of particulate matter (PM) Emissions, diesel oxidation catalyst (DOC) and PM Control, diesel particulate filter (DPF) after-treatment device.

UNIT-III

Automotive Electronic Engine Control and Sensors used in cars

Basics of electronic engine control, engine mapping, air flow rate sensor, manifold absolute pressure (MAP) sensor, engine crankshaft angular position sensor, engine speed sensor, timing sensor for ignition and fuel delivery, throttle angle sensor, temperature sensor, knock sensors, electric motors for hybrid/electric vehicles.

UNIT-IV

Alternative fuels for I C Engines: Biodiesel: properties, advantages and limitations; **Bioethanol:** properties, advantages and limitations; **CNG:** properties, advantages and limitations; **Hydrogen:** Properties, advantages and limitations

Fuel Characteristics Quality Testing: ASTM and European standards for measurement of bio-fuel quality characteristics, density, API density, specific gravity, kinematic viscosity, acid value, flash point and fire point, carbon residue, oxidation stability analysis.

Text/ Reference Books:

1. Hua Zhao, "HCCI and CAI engines for the automotive industry", published by CRC Press, Woodhead Publishing Limited, Cambridge England.
2. Dhananjay Kumar Srivastava, 'Advances in Internal Combustion Engine Research 'published by Springer Nature.
3. William B. Ribbens, "Understanding automotive Electronics", published by Newnes, Elsevier Science, USA.
4. Amit Sarin, "Biodiesel: Production and Properties" Published by the Royal Society of Chemistry.
5. Ronald K. Jurgen, "Automotive Electronic Handbook" by, McGraw-Hill, USA.
6. Wiliam B. Ribbens, "Understanding Automotive Electronics", Newnes, Butterworth–Heinemann.
7. Timothy T. Maxwell, "Alternative Fuel: Emission, Economic and Performance", SAE, 1995.

Note: The paper will have a total of NINE questions. Question No. 1, which is compulsory, shall be Short Answer or Objective Type and have contents from the entire syllabus (all Four Units).

All questions will carry equal **weightage of 12 marks**. The student will attempt a total of **FIVE questions,** each of 12 marks. Q. No. 1 is compulsory. The student shall attempt remaining four questions by selecting **only one question from each unit**

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-II

MTTE-104	STEAM ENGINEERING						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
3	-	-	3	60	40	100	3
Objective	To familiarize the students with the fundamentals of steam engineering and thermal systems for energy conservation and waste heat recovery.						
Course Outcomes							
CO 1	Students will have the ability to explain working of different boilers and significance of mountings and accessories, usage of techniques, skills, and modern engineering tools necessary for boiler performance assessment.						
CO 2	Students will have a theoretical and practical background in thermal systems and will have a good understanding of energy conservation fundamentals. Students will have the ability to analyze thermal systems for energy conservation.						
CO 3	Students will have the ability to design a steam piping system, its components for a process and also design economical and effective insulation.						
CO 4	Students will have the ability to analyze a thermal system for sources of waste heat design a system for waste heat recovery. Students will have the ability to design and develop controls and instrumentation for effective monitoring of the process.						

UNIT-I

Fundamentals of steam generation: Introduction, quality of steam, use of steam table, Mollier chart.
Boilers: Types, mountings and accessories, combustion in boilers, determination of adiabatic flame temperature, quantity of flue gases, feed water and its quality, blow down; IBR, boiler standards.

UNIT-II

Steam Systems: Assessment of steam distribution losses, steam leakages, steam trapping, condensate and flash steam recovery system, steam engineering practices; steam based equipments / systems.
Piping & Insulation: Water line, steam line design and insulation; insulation-types and application, economic thickness of insulation, heat savings and application criteria, refractory-types, selection and application of refractory, heat loss.

UNIT-III

Boiler Performance Assessment Performance: Test codes and procedure, boiler efficiency, analysis of losses; performance evaluation of accessories; factors affecting boiler performance.

Energy Conservation and Waste Minimization: Energy conservation options in boiler; waste minimization, methodology; economical viability of waste minimization.

UNIT-IV

Instrumentation & Control: Process instrumentation; control and monitoring. flow, pressure and temperature measuring and controlling instruments, its selection.

Reference/Text Books:

1. T. D. Estop, A. McConkey, “Applied Thermodynamics”, Parson Publication.
2. Domkundwar; “A Course in Power Plant Engineering”, Dhanapat Rai and Sons.
3. Yunus A. Cengel and Boles, “Engineering Thermodynamics”, Tata McGraw-Hill Publishing Co. Ltd.
4. Book II - Energy Efficiency in Thermal Utilities; Bureau of Energy Efficiency.

5. Book IV - Energy Performance Assessment for Equipment & Utility Systems; Bureau of Energy Efficiency.

6. Edited by J. B. Kitto & S C Stultz, "Steam: Its Generation and Use", The Babcock and Wilcox Company.

7. P. Chatopadhyay, "Boiler Operation Engineering: Questions and Answers", Tata McGraw Hill Education Pvt Ltd, N Delhi.

Note: The paper will have a total of NINE questions. Question No. 1, which is compulsory, shall be Short Answer or Objective Type and have contents from the entire syllabus (all Four Units).

All questions will carry equal **weightage of 12 marks**. The student will attempt a total of **FIVE questions,** each of 12 marks. Q. No. 1 is compulsory. The student shall attempt remaining four questions by selecting **only one question from each unit**

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-II

MTTE-118	ADVANCED INTERNAL COMBUSTION ENGINES LAB							
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Practical Marks	Total	Time (Hrs.)
-	-	4	2	-	40	60	100	3
Objective	To develop capacity to find performance Testing of Engines and determine fuels quality characteristics using different experiments.							
Course Outcomes:								
CO 1	Students will be able to test the performance of Multi Cylinder Diesel Engine and VCR Single Cylinder engine test rig.							
CO 2	Students will be able to determine the exhaust emissions from engines using Smoke meter and gas analyser.							
CO 4	Students will be able to find experimentally the performance of reciprocating air							
CO 3	Students will have the capability to experimentally determine Viscosity, Density and Carbon residue content in a fuel.							
CO 5	Students will have the ability to experimentally determine Cloud, pour point, Flash point and Fire point of any fuel.							

List of Experiments

1. To perform load test on Multi cylinder Diesel engine using biodiesel blends and study its performance.
2. To analyze the performance of single cylinder VCR Diesel Engine with Electronic Control Unit [Computerised].
3. To conduct a load test on a single cylinder, 4-stroke variable compression ratio petrol engine and study its performance under various compression ratios.[Computerised].
4. To analyze the smoke emissions of a Diesel Engine using microprocessor-based Smoke meter.
5. To analyze various exhaust gases of I.C. Engines through a gas analyzer.
6. To conduct performance test on reciprocating air compressor, to determine its volumetric efficiency and Isothermal efficiency.
7. To Determine Viscosity of a fuel using Red Wood Viscometer.
8. To Determine Flash Point and Fire Point of a fuel.
9. To estimate Density, specific Gravity and API density of fuels.
10. To Determine the Carbon residue of a fuel using Ramsbottom Carbon residue apparatus
11. To perform Cloud and pour point test for a fuel.

Note: Total eight experiments are to be performed selecting at least six from the above list. Remaining two experiments can be from the above list or Teacher may design any two experiments based on the availability of the facilities in the lab.

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-II

MTTE-120	COMPUTATIONAL FLUID DYNAMICS LAB							
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Practical Marks	Total	Time (Hrs.)
-	-	4	2	-	40	60	100	3
Objective	To acquaint the students with fundamentals of programming and simulation of 1 D and 2 D heat transfer and fluid flow problems using finite differencing and finite volume. To provide students with the necessary skills to use commercial CFD packages.							
Course Outcomes								
CO 1	Students will able to develop an understanding of the difference between dimensional and non-dimensional programming techniques.							
CO 2	Students will able to understand the fundamentals of programming/simulation of heat transfer in pin fin problems.							
CO 3	Students will able to understand the fundamentals of programming/simulation of fluid flow problems.							
CO 4	Students will able to understand the fundamentals of programming/simulation of steady and transient heat conduction problems.							

List of Experiments

1 To make and validate a computer programme for the one dimensional pin fin steady state heat conduction when fin is infinitely long in dimensional and non-dimensional form.
2 To make and validate a computer programme for the one dimensional pin fin steady state heat conduction when fin is insulated at tip in dimensional and non-dimensional form.
3 To make and validate a computer programme for the one dimensional pin fin steady state heat conduction when fin is losing heat at tip in dimensional and non-dimensional form.
4 To make and validate a computer programme for the one dimensional transient heat conduction.
5 To make and validate a computer programme for the plate in two dimensions in steady state conduction.
6 To make and validate a computer programme for the plate in two dimensions in transient state.
7 To make and validate a computer programme for the comparison of explicit, implicit, semi- implicit method of computation of heat transfer equation.
8 To make and validate a computer programme for the fully developed laminar flow in circular pipe.
9 To make and validate a computer programme for the Coutte flow.
10 To simulate and analyze the transonic flow over an airfoil.
11 To simulate vortex shedding phenomenon over a cylinder in laminar flow.
12 To simulate and analyze the flow through a venturimeter.
13 To simulate and analyze the laminar pipe flow.
14 To simulate and analyze the laminar pipe flow.
15 To simulate and analyze the compressible flow through a nozzle.

Note: Total eight experiments are to be performed selecting at least six from the above list. The programs may be validated using any software.

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-II

MTTE-122	MINI PROJECT						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
-	-	4	2	-	100	100	3
Objective	**In case of mini project, they will solve a live problem using software/analytical/computational tools or fabricate an experimental setup.**						
Course Outcomes							
CO 1	**Students will learn to write technical reports.**						
CO 2	**Students will develop skills to present and defend their work in front of technically qualified audience.**						

Students can take up small problems in the field of design engineering as mini project. It can be related to solution to an engineering problem, verification and analysis of experimental data available, conducting experiments on various engineering subjects, material characterization, studying a software tool for the solution of an engineering problem etc.

Students will be required to submit a brief synopsis of 3-4 pages related to the topic by the first week of September.

Program Elective - III

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-II

MTTE-106	DESIGN OF SOLAR AND WIND SYSTEMS						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
3	-	-	3	60	40	100	3
Objective	To acquaint the students with fundamentals of solar and wind systems and devices.						
Course Outcomes							
CO 1	Students will learn about the technological status of implementation of NCES in India						
CO 2	Student will be capable to analyze various techno economical obstacles in the commercial development of NCES in India						
CO 3	Student will be capable to conceptually model and design general NCES systems and predict the long term performance.						
CO 4	Student will suggest and plan hybrid NCES solutions to conventional energy systems						

Unit-I

Fundamental of energy science and technology: Energy, economy and social development, classification of energy sources, energy scenario in India.

Conventional sources of energy: Consumption trend of primary energy sources, energy-environment economy, Nuclear, Alternative energy sources.

Unit-II

Solar Radiation: Estimation, prediction & measurement, solar energy utilization, extraterrestrial and terrestrial radiations, spectral power distribution of solar radiation, solar time, and solar radiation geometry, Estimation of solar radiation on horizontal and tilted surface.

Solar Thermal Systems: Solar water heater, solar cooker, solar furnace, solar dryer, solar distillation, solar greenhouse.

Unit-III

Solar radiation collector: Performance of solar flat plate collectors, concentrating collectors.

Thermal storage: Sensible, latent and chemical heat storage. solar air heaters, solar air-conditioning systems, application of solar energy for drying and farm operations; water pumping, heating applications of solar energy, thermal power systems.

Unit-IV

Wind energy: Direct energy conversion- PV, magneto hydro dynamo, wind mill, site selection for wind mill.

Non-conventional Energy Technologies: Fuel cells, thermionic, thermoelectric, biomass, biogas, hydrogen, geothermal.

Reference/Text Books:

1. D.Y. Goswami, F. Kreith and J.F. Kreider, "Principle of Solar Engineering", Taylor and Francis, 2000.
2. Sukhatme S.P., "Solar Energy", Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1994.
3. J.F. Kreider, F. Kreith, "Solar Energy Handbook", McGraw Hill, 1981

4. J.A. Duffie and W.A. Beckman, “Solar Engineering of Thermal Processes”, John Wiley, 1991.

Note: The paper will have a total of NINE questions. Question No. 1, which is compulsory, shall be Short Answer or Objective Type and have contents from the entire syllabus (all Four Units).

All questions will carry equal **weightage of 12 marks**. The student will attempt a total of **FIVE questions,** each of 12 marks. Q. No. 1 is compulsory. The student shall attempt remaining four questions by selecting **only one question from each unit**

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-II

MTTE-108	NUCLEAR ENGINEERING						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
3	-	-	3	60	40	100	3
Objective	To impart knowledge of Nuclear Reactor: inside processes, energy release, criticality, types, dimensions, materials, control, behavior, heat removal, safety, radiation protection, isotopes.						
Course Outcomes							
CO 1	Students will able to inculcate the basic concepts and processes taking place inside a nuclear reactor, such as nuclear fission, neutron production, scattering, diffusion, slowing down and absorption.						
CO 2	Students will get familiarized with the concepts of energy release, reactor criticality, the relationship between the dimension and fissile material concentration in a critical geometry.						
CO 3	Students will be able to explain the time dependent (transient) behavior of power reactor in non-steady state operation and will gain the knowledge about the means to control the nuclear reactor & its types.						
CO 4	Students will be able to extend the concepts of heat transfer in nuclear reactor cores. They will understand the mandatory safety precautions required in nuclear reactors and its radiations. They will gain the knowledge of applications of different radio-isotopes.						

UNIT-I

Nuclear Physics: Introduction; atom, nucleus & their structure; atomic transmutation; radioactivity detection; concepts of particle accelerator; radioactivity, radioactive decay, decay rate & half-life; nucleus interactions; transuranic elements; nuclear reactions: cross sections, nuclear fission & fusion, conversion and breeding.

Neutron transport and diffusion: Introduction; neutron transport equation; Fick's laws of diffusion: Ist and IInd Law; Solution to diffusion equation: instantaneous point source, infinite planar source; energy loss in elastic collisions, neutron slowing down.

UNIT-II

Energy and Exergy: Mass energy equivalence; mass defect; binding energy; energy release in fission & fusion; thermonuclear reaction; fusion bomb; exergy concept.

Reactor Mechanics and its governing equations: Solution of multigroup diffusion equations in one region and multi-region reactors; Concept of criticality of thermal reactors; reactor materials fissile & fertile materials; cladding & shielding materials, moderators, coolants.

UNIT-III

Reactor kinetics and Stability: Basic principles; fuel assembly; neutron balance; reactor kinetics; derivation of point kinetics equations; in-hour equation; solutions for simple cases of reactivity additions; excess reactivity; reactivity control; reactor stability; fission product poison or xenon poisoning; reactivity coefficients; burnable absorbers.

Classification of Nuclear Reactors: Pressurized water reactors; boiling water reactors; CANDU type reactors; gas cooled & liquid metal cooled reactors; fast breeder reactors.

UNIT-IV

Heat Transfer in Nuclear Reactors: Heat transfer equation solution in reactor core; temperature distribution; critical heat flux; heat balance; production & transfer of heat to the coolant; structural considerations.

Safety Precautions, Prevention & Isotopes: Reactor safety philosophy; defense in depth; units of radioactivity exposure; radiation protection standards; waste disposal hazards; plant site selection; safety measures incorporated in: plant design, accident control, disposal of nuclear waste, health physics; radio-isotopes radiation: units, hazards, prevention; preparation of radio-isotopes & their use in medicine, agriculture & industry.

Reference/Text Books:

1. M.M. El-Wakel, 'Nuclear Power Engineering". McGraw-Hill Inc., US
2. John R Lamarsh, "Introduction to nuclear engineering", Pearson Publication
3. J.J. Duderstadt, L. J. Hamilton, "Nuclear reactor analysis" Wiley publication

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MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-II

MTTE-110	CONVECTIVE HEAT TRANSFER						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
3	-	-	3	60	40	100	3
Objective	To impart an in depth knowledge about the fundamentals and applications of the convective heat transfer.						
Course Outcomes							
CO 1	Students will learn the fundamentals of convective heat transfer.						
CO 2	Students will be able to understand laminar forced convection external and internal flows.						
CO 3	Students will develop an understanding of boundary layer flow in external and internal natural convection.						
CO 4	Students will be able to analyze the turbulent boundary layer and duct flows.						
CO 5	Students will understand the mechanism of phase change and convection in porous media.						

UNIT-I

Review of Governing Equations: Continuity, momentum and energy equations, second law of thermodynamics, scale analysis, concept of heat line visualization.

Laminar External Forced Convection: Boundary layer concept, velocity and thermal boundary layers, governing equations, similarity solutions, correlations, various wall heating conditions, Flow past a wedge and stagnation flow, blowing and suction, entropy generation minimization, heat lines in laminar boundary layer flow, numerical problems.

Laminar Internal Forced Convection: Fully developed laminar flow, heat transfer to fully developed duct flow, constant heat flux and constant wall temperature, heat transfer to developing flow, correlations, heat lines in fully developed duct flow.

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UNIT-II

External Free Convection: Boundary layer equations, scale analysis, low and high Prandtl number fluids, integral solution, similarity solution, uniform heat wall flux, conjugate boundary layers, vertical channel flow, combined natural and forced convection, vertical walls, horizontal walls, inclined walls, horizontal and vertical cylinder, sphere, correlations, numerical problems.

Internal Free Convection: transient heating from side, boundary layer regime, isothermal and constant heat flux side walls, partially divided and triangular enclosures, and enclosures heated from below, inclined enclosures, annular space between horizontal cylinders and concentric spheres.

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UNIT-III

Transition to Turbulence: empirical transition data, scaling laws of transition, buckling of inviscid streams, instability of inviscid flow.

Turbulent Boundary Layer Flow: Boundary layer equations, mixing length model, velocity distribution, heat transfer in boundary layer flow, flow over single cylinder, cross flow over array of cylinders, natural convection along vertical walls.

Turbulent duct flow: Velocity distribution, friction factor and pressure drop, heat transfer coefficient, isothermal wall, uniform wall heating, heat lines in turbulent flow near a wall, optimal channel spacing, empirical correlations for different configurations.

UNIT-IV

Convection with Change of Phase: Condensation, laminar and turbulent film on a vertical surface, film condensation, drop condensation, boiling, pool boiling regimes, nucleate boiling, film boiling and flow boiling, contact melting and lubrication, melting by natural convection.

Convection in Porous Media: Mass conservation, Darcy and Forchheimer flow models, enclosed porous media heated from side, penetrative convection, enclosed porous media heated from below.

Reference/Text Books:

1. A. Bejan, "Convection Heat Transfer", Wiley Publications.
2. Louis C. Burmeister, "Convective Heat Transfer", Wiley Publications.
3. W. M. Kays and M. E. Crawford, "Convective Heat and Mass Transfer", McGraw Hill.
4. E.R.G. Eckert and Robert M. Drake, "Analysis of heat and mass transfer", McGraw Hill.
5. S. Kakac and Y. Yener, "Convective Heat Transfer", CRC Press.

Note: The paper will have a total of NINE questions. Question No. 1, which is compulsory, shall be Short Answer or Objective Type and have contents from the entire syllabus (all Four Units).

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Program Elective – IV

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-II

MTTE-112	COMPUTATIONAL FLUID DYNAMICS						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
3	-	-	3	60	40	100	3
Objective	To familiarize the students with the basic concepts of Computational Fluid Dynamics and problem solving approach using CFD.						
Course Outcomes							
CO 1	The students will develop an understanding of fundamental concepts of computational fluid dynamics.						
CO 2	The students will be able to model the basic equations which govern the fluid flow and heat transfer phenomena and analyze their mathematical behaviour.						
CO 3	The students will understand the basic concepts of discretization, error analysis and will develop the understanding of some simple CFD techniques.						
CO 4	The students will be able to analyze the steady and unsteady heat conduction & combined conduction diffusion problems using control volume formulation.						
CO 5	The students will be able to apply CFD to actual fluid flow problems.						

UNIT-I

Introduction: Introduction to C.F.D., comparison of the three basic approaches in engineering problem solving- analytical, experimental and computational.

Review of Governing Equations: models of the flow, substantial derivative, governing equations – continuity equation, momentum equation, energy equation, Navier-Stokes equation; physical boundary conditions.

Mathematical behavior of governing equations: classification of quasi linear partial differential equations, general method of determining the classification of partial differential equations, general behavior of hyperbolic, parabolic, elliptic equations.

UNIT-II

Discretization: Basic aspects of discretization, finite difference method, difference equations, explicit and implicit approaches, truncation error, round-off and discretization error, consistency and stability, convergence of a marching problem, methods for obtaining difference equations: use of Taylor series, use of polynomial fitting, integral method, finite volume method; stability analysis, grid generation, use of irregular mesh.

UNIT-III

Heat Conduction: control volume formulation of one-dimensional steady state diffusion, grid spacing, interface conductivity, non-linearity, source term linearization, boundary conditions; unsteady one-dimensional diffusion, two and three dimensional diffusion problems, over and under relaxation.

Convection & Diffusion: Steady one-dimensional convection and diffusion, central differencing scheme, upwind differencing scheme, exact solution, exponential, hybrid, and power law schemes, discretization equations for two dimensions & three dimensions, false diffusion.

UNIT-IV

Simple CFD Techniques: Lax-Wendroff technique, MacCormack's technique, space marching, relaxation technique, pressure correction technique, SIMPLE and SIMPLER algorithms.

Fluid Flow: CFD solution of subsonic-supersonic isentropic nozzle flow, solution of incompressible Couette flow problem by F.D.M., solution of Navier-Stokes equations for incompressible flows using MAC and SIMPLE methods.

Reference/Text Books:

1. Suhas V. Patankar, “Numerical Heat Transfer and Fluid Flow”, CRC Press.
2. John D. Anderson, Jr, “Computational Fluid Dynamics”, McGraw Hill Education.
3. H. Versteeg & W. Malalasekra, “An Introduction to Computational Fluid Dynamics”, Pearson.
4. Richard H. Pletcher, John C. Tannehill, Dale Anderson, “Computational Fluid Mechanics and Heat Transfer”, CRC Press.
5. Atul Sharma, “An Introduction to CFD: Development, Application & Analysis”, Ane/Athena Books.
6. K. Muralidhar & T. Sundararajan, “Computational Fluid Flow & Heat Transfer”, Alpha Science Intl Ltd.
7. Anil W. Date, “Introduction to Computational Fluid Dynamics” Cambridge University Press.
8. J. Blazek, “Computational Fluid Dynamics: Principles and Applications”, Elsevier Science & Technology.
9. T.J. Chung, “Computational Fluid Dynamics”, Cambridge University Press.

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MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-II

MTTE-114	DESIGN OF HEAT TRANSFER EQUIPMENTS						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
3	-	-	3	60	40	100	3
Objective	To impart students with the knowledge of design considerations & operational parameters of a wide variety of Heat Transfer Equipments.						
Course Outcomes							
CO 1	Students will be able to demonstrate a general understanding of heat exchangers viz. shell-and-tube, double pipe, plate-and-frame, finned tube and plate-fin heat exchangers & Heat pipes.						
CO 2	Students will be able to select material, components, design and analyze the shell-and-tube, double pipe, hair-pin and compact plate types of heat exchangers.						
CO 3	Students will be able to demonstrate the knowledge of performance degradation of heat exchangers subject to fouling, pressure drop and surface characteristics of Heat Exchangers.						

UNIT-I

Basic Review & Classification: Introduction to heat transfer and heat transfer euipments; classification of heat transfer equipments on the basis of: heat transfer process, number of fluids, surface compactness, construction features and flow arrangement; tubular heat exchanger; plate type heat exchangers; extended surface heat exchangers; heat pipe; regenerators.
Design methodology: Heat transfer analysis: assumptions & problem formulation; E-NTU & *P*-NTU method; LMTD method; fouling: effects, categorization & fundamental processes.

UNIT-II

Double Pipe Heat Exchangers: Modes of operation; general configuration and characteristics; thermal and hydraulic design of inner tube; thermal and hydraulic analysis of annulus; total pressure drop.
Compact Heat Exchangers: Modes of operation; general configuration and characteristics; thermal and hydraulic design.
Shell & Tube heat exchangers: Modes of operation; general configuration and characteristics; Tinker's, Kern's and Bell Delaware's methods for thermal and hydraulic design.

UNIT-III

Pressure Drop Analysis: Importance of pressure drop; devices; extended surface heat exchanger pressure drop; tubular heat exchanger pressure drop; tube banks; shell and tube exchangers; plate heat exchanger pressure drop; pipe losses; non-dimensional presentation of pressure drop data.
Surface Characteristics and Techniques: Dimensionless surface characteristics; heat exchanger surface geometrical characteristics; experimental techniques for determining surface characteristics; steady-state kays and London technique; Wilson plot technique; transient test techniques; friction factor determination.

UNIT-IV

Material Selection & Design of Heat Exchangers: Selection of heat exchangers and their components; temperature difference distributions; design standards and codes; terminology in heat exchanger design; material selection, and thickness calculation for major components such as tube sheet, shell, tubes, flanges and nozzles; Introduction to simulation and optimization of heat exchangers; flow induced vibrations.

Hair-Pin Heat Exchangers: Introduction; industrial HPHE; film coefficients in tubes and annuli; pressure drop; augmentation in performance of HPHE; series and parallel arrangements; comprehensive design algorithm; numerical problems.

Reference/Text Books:

1. Ramesh K. Shah and Dusan P. Sekulic, "Fundamentals of Heat Exchanger Design" John Wiley & sons Inc., 2003.
2. D.C. Kern, "Process Heat Transfer", McGraw Hill, 1950.
3. Sadik Kakac and Hongton Liu, "Heat Exchangers: Selection, Rating and Thermal Design" CRC Press, 1998.
4. A .P. Frass and M.N. Ozisik, "Heat Exchanger Design", McGraw Hill, 1984
5. Afgan N. and Schlinder E.V. "Heat Exchanger Design and Theory Source Book".
6. T. Kuppan, "Hand Book of Heat Exchanger Design".
7. "T.E.M.A. Standard", New York, 1999.
8. G. Walkers, "Industrial Heat Exchangers-A Basic Guide", McGraw Hill, 1982.

Note: The paper will have a total of NINE questions. Question No. 1, which is compulsory, shall be Short Answer or Objective Type and have contents from the entire syllabus (all Four Units).

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MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-II

MTTE-116	COMPRESSIBLE FLOW MACHINES						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
3	-	-	3	60	40	100	3
Objective	To understand the various fluid devices like turbine, compressors, pumps etc. Also to understand the concepts of shock waves and their properties.						
Course Outcomes							
CO 1	Students will able to understand the basic concepts of fluid machines. Also to learn the concepts of various turbines along with their general equations of power developed.						
CO 2	Students will able to understand the various types of pumps along with their advantages, disadvantages and applications.						
CO 3	Students will study the various compressors, diffusers & flow through variable area ducts. Also to learn the various terms and parts related to these devices.						
CO 4	Students will able to understand the basic concepts of shock waves. Also to learn the various types of shock waves through various equations.						
CO 5	Students will able to understand the basic concepts of fluid machines. Also to learn the concepts of various turbines along with their general equations of power developed.						

UNIT-I

Introduction*:* Introduction to fluid machines, energy transfer in fluid machines, energy transfer-impulse and reaction machines, efficiencies of fluid machines, principles of similarity in fluid machines, concept of specific speed and introduction to impulse hydraulic turbine.
Turbines: Analysis of force on the bucket of Pelton wheel and power generation, specific speed, governing and limitation of a Pelton turbine, introduction to reaction type of hydraulic turbine- a Francis turbine, analysis of force on Francis runner and power generation, axial flow machine and draft tube, governing of reaction turbine.

UNIT-II

Pumps: Introduction to rotodynamic pumps, flow and energy transfer in a centrifugal pump, characteristics of a centrifugal pump, matching of pump and system characteristics, diffuser and cavitation, axial flow pump, reciprocating pump.

UNIT-III

Compressors: Centrifugal and axial flow compressor, their characteristics.
Flow through Diffusers: Classification of diffusers, internal compression subsonic diffusers, velocity gradient, effect of friction and area change, the conical internal-compression subsonic diffusers, external compression subsonic diffusers, supersonic diffusers, normal shock supersonic diffusers, the converging diverging supersonic diffusers.
Flow through variable area ducts: Isentropic flow through variable area ducts, T-S and H-S diagrams for nozzle and diffuser flows, area ratio as a function of Mach number, mass flow rate through nozzles and diffusers, effect of friction in flow through nozzles.

UNIT-IV

Shock wave: Introduction to compressible flow, thermodynamic relations and speed of sound, disturbance propagation, stagnation and sonic properties, effects of area variation on properties in an isentropic flow, choking in a converging nozzle, isentropic flow through convergent-divergent duct, normal shock, oblique shock**,** introduction to expansion wave and Prandtl Meyer Flow**.**

Reference/Text Books:

1. S. M. Yahya, "Fundamentals of Compressible Flow", New Age International.
2. S.M. Yahya, "Turbines, Compressors and Fans", Tata McGraw Hill.
3. P.H. Oosthvizen and W.E. Carscallen, "Compressible Fluid Flow", McGraw Hill.

Note: The paper will have a total of NINE questions. Question No. 1, which is compulsory, shall be Short Answer or Objective Type and have contents from the entire syllabus (all Four Units).

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Audit Course - II

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-II

MTAD- 202	CONSTITUTION OF INDIA						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
2	-	-	-	-	100	100	3
Objective	Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective and to address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.						
Course Outcomes							
CO1	Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.						
CO2	Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.						
CO3	Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.						
CO4	Discuss the passage of the Hindu Code Bill of 1956.						

Unit-I

History of Making of the Indian Constitution: History, Drafting Committee, (Composition & Working)
Philosophy of the Indian Constitution: Preamble, Salient Features

Unit-II

Contours of Constitutional Rights & Duties: Fundamental Rights , Right to Equality, Right to Freedom , Right against Exploitation , Right to Freedom of Religion, Cultural and Educational Rights , Right to Constitutional Remedies , Directive Principles of State Policy , Fundamental Duties.

Organs of Governance: Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications. Powers and Functions

Unit-III

Local Administration: District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative CEO of Municipal Corporation, Pachayati raj: Introduction, PRI: Zila Pachayat, Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy

Unit-IV

Election Commission: Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners. State Election Commission: Role and Functioning. Institute and Bodies for the welfare of SC/ST/OBC and women.

Reference/Text Books:

1. The Constitution of India, 1950 (Bare Act), Government Publication.

2. Dr. S. N. Busi, Dr. B. R. Ambedkar, “framing of Indian Constitution”, 1st Edition, 2015.
3. M. P. Jain, “Indian Constitution Law”, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, “Introduction to the Constitution of India”, Lexis Nexis, 2015.

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-II

MTAD-204	PEDAGOGY STUDIES						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
2	-	-	-	-	100	100	3
Objective	Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers and Identify critical evidence gaps to guide the development.						
Course Outcomes							
CO1	Understand the pedagogical practices being used by teachers in formal and informal classrooms in developing countries.						
CO2	Become aware of the evidence on the effectiveness of these pedagogical practices, in different conditions and with different population of learners.						
CO3	Understand the significance of teacher education (curriculum and practicum) and the school curriculum and guidance materials for effective pedagogy.						

Unit-I

Introduction and Methodology: Aims and rationale, Policy background, Conceptual framework and terminology, Theories of learning, Curriculum, Teacher education, Conceptual framework, Research questions. Overview of methodology and Searching.

Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries, Curriculum, Teacher education.

Unit-II

Evidence on the effectiveness of pedagogical practices, Methodology for the in depth stage: quality assessment of included studies. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? Theory of change. Strength and nature of the body of evidence for effective pedagogical practices. Pedagogic theory and pedagogical approaches. Teachers' attitudes and beliefs and Pedagogic strategies.

Unit-III

Professional development: alignment with classroom practices and follow-up support, Peer support Support from the head teacher and the community. Curriculum and assessment, Barriers to learning: limited resources and large class sizes.

Unit-IV

Research gaps and future directions: Research design, Contexts, Pedagogy, Teacher education Curriculum and assessment, Dissemination and research impact.

References/Text Books:

1. Ackers J, Hardman F, "Classroom interaction in Kenyan primary schools", Compare, 31 (2): 245-261.

2. Agrawal M, "Curricular reform in schools: The importance of evaluation", Journal of Curriculum Studies, 36 (3): 361-379.

3.Akyeampong K, "Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.

4.Akyeampong K, Lussier K, Pryor J, Westbrook J, “Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count?” International Journal Educational Development, 33 (3): 272–282.
5.Alexander RJ, “Culture and pedagogy: International comparisons in primary education”. Oxford and Boston: Blackwell.
6.Chavan M, “Read India: A mass scale, rapid, ‘learning to read’ campaign”.

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-II

MTAD-206	STRESS MANAGEMENT BY YOGA						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
2	-	-	-	-	100	100	3
Objective	To achieve overall health of body and mind and to overcome stress						
Course Outcomes							
CO1	Develop healthy mind in a healthy body thus improving social health.						
CO2	Improve efficiency						
CO3	Learn the Yogasan						
CO4	Learn the pranayama						

Unit-I

Definitions of Eight parts of yog. (Ashtanga)

Unit-II

Yam and Niyam. Do`s and Don't's in life.

i) Ahinsa, satya, astheya, bramhacharya and aparigraha ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan

Unit-III

Asan and Pranayam

i) Various yog poses and their benefits for mind & body ii) Regularization of breathing techniques and its effects-Types of pranayam

Reference/Text Books:

1. Janardan Swami Yogabhyasi Mandal, "Yogic Asanas for Group Tarining-Part-I" : Nagpur
2. Swami Vivekananda, "Rajayoga or conquering the Internal Nature" Advaita Ashrama (Publication Department), Kolkata

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
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Semester-II

MTAD-208	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
2	**-**	**-**	**-**	**-**	**100**	**100**	**3**
Objective	To learn to achieve the highest goal happily To become a person with stable mind, pleasing personality and determination To awaken wisdom in students						
Course Outcomes							
CO1	**Students become aware about leadership.**						
CO2	**Students will learn how to improve communication skills**						
CO3	**Understand the team building and conflict**						
CO4	**Student will learn how to manage the time.**						

Neetisatakam-Holistic development of personality

i) Verses- 19,20,21,22 (wisdom)
ii) Verses- 29,31,32 (pride & heroism)
iii) Verses- 26,28,63,65 (virtue)
iv) Verses- 52,53,59 (dont's)
v) Verses- 71,73,75,78 (do's)

Approach to day to day work and duties.
Shrimad Bhagwad Geeta : Chapter 2-Verses 41, 47,48,
Chapter 3-Verses 13, 21, 27, 35,
Chapter 6-Verses 5,13,17, 23, 35,
Chapter 18-Verses 45, 46, 48.

Statements of basic knowledge.
Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68
Chapter 12 -Verses 13, 14, 15, 16,17, 18

Personality of Role model. Shrimad Bhagwad Geeta:
Chapter 2-Verses 17,
Chapter 3-Verses 36, 37, 42,
Chapter 4-Verses 18, 38, 39
Chapter18 – Verses 37, 38, 63

Reference/Text Books:

1. Swami Swarupananda, "Srimad Bhagavad Gita" Advaita Ashram (Publication Department), Kolkata
2. P.Gopinath, "Bhartrihari's Three Satakam (Niti-sringar-vairagya) by, Rashtriya Sanskrit Sansthanam, New Delhi.

Third Semester

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-III

MTTE-207	DISSERTATION PHASE - I							
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Practical Marks	Total	Time (Hrs.)
-	-	20	10	-	100	-	100	-
Objective	The main objective of this course is to plan a research work (which includes the problem formulation/literature review, proposed objectives, proposed methodologies and references) in the field of Thermal Engineering or interrelated fields of applications.							
Course Outcomes								
CO 1	Students will be exposed to self-learning various topics.							
CO 2	Students will learn to survey the literature such as books, national/international refereed journals and contact resource persons for the selected topic of research.							
CO 3	Students will learn to write technical reports.							
CO 4	Students will develop oral and written communication skills to present and defend their work in front of technically qualified audience.							

The Project Work will start in semester III and should preferably be a problem with research potential and should involve scientific research, design, generation/collection and analysis of data, determining solution and must preferably bring out the individual contribution.

The examination shall consist of the preparation of report consisting of a detailed problem statement and a literature review. The preliminary results (if available) of the problem may also be discussed in the report. The work has to be presented in front of the examiners panel set by Head and PG coordinator. The candidate has to be in regular contact with his/her supervisor and the topic of dissertation must be mutually decided by the supervisor and student.

The students will be required to submit a progress report related to their dissertation work by the end of September. The progress report will cover the following:

- The goal set for the period.
- Research papers studied.
- Methodology used in achieving the goal.
- The extent of fulfillment of the goal.

The progress report must be at least of 3-4 pages and the cover page should include the tentative topic, name of the candidate, name of the supervisor, period of progress report, signature of candidate and supervisor.

The students will be required to appear for comprehensive Seminar & Viva-voce and submit a synopsis report based on their progress related to the dissertation as per the presentation dates mentioned in the academic calendar for the session. The synopsis report will be submitted in the same format as that of the thesis and will contain the following:

1. Introduction
2. Literature Survey
3. Gaps in Literature
4. Objectives of the Proposed Work

5. Methodology
6. References

* Student will choose his/her guide in the end of second semester

Program Elective – V

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-III

MTTE-201	ADVANCED COMPUTATIONAL FLUID DYNAMICS						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
3	-	-	3	60	40	100	3

Objective	To familiarize the students with the advanced concepts of Computational Fluid Dynamics.
Course Outcomes	
CO 1	Students will be able to develop the understanding of the modeling of turbulence and its effects.
CO 2	Students will be able to analyze the convection diffusion problems and develop algorithms for pressure velocity coupling in steady flows and unsteady flows.
CO 3	Students will be able to develop skills to implement and handle boundary conditions; errors and uncertainty; and complex geometries.
CO 4	Students will be able to model the combustion phenomenon and radiative heat transfer using CFD.

UNIT-I

Introduction: Revision of pre-requisite courses, finite differences and finite volume methods.

Turbulence and its modeling: Transition from laminar to turbulent flow, descriptors of turbulent flow, averaged equations for turbulent flow, characteristics of turbulent flow, effect of turbulent fluctuations on mean flow, turbulent flow calculations, turbulence modeling, Reylolds stress models, large-eddy simulation, direct numerical simulation.

UNIT-II

Finite volume method for convection-diffusion problems: Steady 1-D convection-diffusion, conservativeness, boundedness and transportiveness, central, upwind, hybrid and power law schemes, QUICK and TVD schemes.

Implementation of boundary conditions: Inlet, outlet, and wall boundary conditions, pressure boundary condition, cyclic or symmetric boundary condition.

Errors and uncertainty in CFD modeling: Errors and uncertainty in CFD, numerical errors, input uncertainty, physical model uncertainty, verification and validation, guide lines for best practices in CFD, reporting and documentation of CFD results.

UNIT-III

Pressure - velocity coupling in steady flows: Staggered grid, SIMPLE algorithm, assembly of a complete method, SIMPLER, SIMPLEC and PISO algorithms, worked examples of the above algorithms.

Finite volume method for unsteady flows: 1-D unsteady heat conduction, explicit, Crank-Nicolson and fully implicit schemes, transient problems with QUICK, SIMPLE schemes.

Methods for Dealing with complex geometries: Introduction, body-fitted co-ordinate grids, curvilinear grids, block structured and unstructured grids, discretization in unstructured grids, diffusion and convective term, assembly of discretized equations, pressure-velocity coupling, extension of face velocity interpolation method to unstructured meshes.

UNIT-IV

CFD modeling of combustion: Enthalpy of formation, Stoichiometry, equivalence ratio, adiabatic flame temperature, equilibrium and dissociation, governing equations of combusting flows, modeling of a laminar diffusion flame, SCRC model for turbulent combustion, probability density function approach, eddy break up model.

CFD for radiation heat transfer: Governing equations for radiation heat transfer, popular radiation calculation techniques using CFD, The Monte Carlo method, the discrete transfer method, Ray tracing, the discrete ordinates method.

Reference/Text Books:

1. H. Versteeg & W. Malalasekra, "An Introduction to Computational Fluid Dynamics", Pearson.
2. Suhas V. Patankar, "Numerical Heat Transfer and Fluid Flow", CRC Press.
3. J.C. Tannehill, D. A. Anderson and R.H. Pletcher, "Computational Fluid Mechnaics and Heat Transfer", CRC Press.
4. J. Blazek, "Computational Fluid Dynamics: Principles and Applications", Elsevier Science & Technology.
5. T.J. Chung, "Computational Fluid Dynamics", Cambridge University Press.

Note: The paper will have a total of NINE questions. Question No. 1, which is compulsory, shall be Short Answer or Objective Type and have contents from the entire syllabus (all Four Units).

All questions will carry equal **weightage of 12 marks**. The student will attempt a total of **FIVE questions,** each of 12 marks. Q. No. 1 is compulsory. The student shall attempt remaining four questions by selecting **only one question from each unit**

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-III

MTTE-203	FINITE ELEMENT METHODS						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
3	-	-	3	60	40	100	3
Objective	To acquaint the students with fundamentals and various methods for solving the finite element problems. Also FDM, convergence and stability of FD scheme.						
Course Outcomes							
CO 1	Students will be able to understand the basic steps in FEM formulation. Also to study various concepts associated and assembly along with the boundary conditions in FEM formulation.						
CO 2	Students will be able to understand how FEM problem is formulated in 1-D elements. Also to discuss shape functions, h and p approximations; and various solvers associated in FEM.						
CO 3	Students will be able to understand FEM formulation of 2-D element using various methods like Galerkin approach, Weighted Residual etc. Also to understand the natural co-ordinates, numerical integration and various other concepts related to 2-D FEM formulation.						
CO 4	Students will be able to understand the axi-symmetric problems along with plane stress and plane strain problems with regards to solid mechanics. Also to discuss various elements of FEM, FEM with CI continuity and FDM problems.						

UNIT-I

Introduction to FEM: Basic Steps in FEM Formulation, General Applicability of the method; variational functional, Ritz method.

Variational FEM: Derivation of elemental equations, assembly, imposition of boundary conditions, solution of the equations.

UNIT-II

1D Elements: Shape functions, convergence criteria, h and p approximations, natural coordinates, numerical integration, gauss elimination based solvers, computer implementation: pre-processor, processor, post-processor.

UNIT-III

Alternate Formulation: Weighted residual method, Galerkin method; problems with C1 continuity:
Beam Bending, Connectivity and Assembly of C1 Continuity Elements.
Variational Functional; 2-D elements (triangles and quadrilaterals) and shape functions, natural coordinates, numerical integration, elemental equations, .connectivity and assembly, imposition of boundary conditions.

UNIT-IV

Fem formulation & problems: Axisymmetric (heat conduction) problem, plane strain and plane stress solid mechanics problems, sub-parametric, iso-parametric and super-parametric elements; elements with C1 continuity, free vibration problems, formulation of Eigen value problem, FEM formulation. time-dependent problems, combination of Galerkin FEM and FDM (finite difference method), convergence and stability of FD scheme.

Reference/Text Books:

1. C. S. Krishnamoorty, “Finite element analysis”, Tata McGraw Hill

2. J. N Reddy, "An introduction to Finite element method", Tata Mc. Graw Hill
3. Y. M. Desai, "Finite Element Method with applications in engineering", Pearson Education India
4. Ted Belytschko, W.K. Liu and Brian Moran, "Nonlinear Finite Elements for Continua and Structures (Paperback)" Wiley-Blackwell (16 August 2000)
5. Guido Dhondt, "The Finite Element Method for Three-Dimensional Thermomechanical Applications", Wiley; 1 edition (June 18, 2004).
6. Claes Johnson, "Numerical Solution of Partial Differential Equations by the Finite Element Method", Dover Publications (January 15, 2009).

Note: The paper will have a total of NINE questions. Question No. 1, which is compulsory, shall be Short Answer or Objective Type and have contents from the entire syllabus (all Four Units).

All questions will carry equal **weightage of 12 marks**. The student will attempt a total of **FIVE questions,** each of 12 marks. Q. No. 1 is compulsory. The student shall attempt remaining four questions by selecting **only one question from each unit**

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-III

MTTE-205	THERMAL MODELING AND ANALYSIS						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
3	-	-	3	60	40	100	3
Objective	To acquaint the knowledge of mathematical modelling and analysis for designing the thermal systems. Also students can able to understand the dynamic behaviour of thermal systems.						
Course Outcomes							
CO 1	Students will be able to understand the basic concepts for designing the thermal systems. Also to discuss mathematical modelling of thermal systems using computer programmes.						
CO 2	Students will be able to equip for modelling the thermal systems like heat exchangers, evaporators, condensers etc. Also to understand their solution procedures.						
CO 3	Students will be able to understand the concepts of optimization and its various methods for solving the thermal problems. Also to study geometric, linear and dynamic programming.						
CO 4	Students will be able to learn the dynamic behaviour of thermal systems. Also to learn stability analysis and non-linearity.						
CO 5	Students will be able to understand the basic concepts for designing the thermal systems. Also to discuss optimization and mathematical modelling of thermal systems using computer programmes.						

UNIT-I

Design of Thermal System: Design principles, workable systems, optimal systems, matching of system components, economic analysis, depreciation, gradient present worth factor.
Mathematical Modeling: Equation fitting, empirical equation, regression analysis, different modes of mathematical models, selection, computer programmes for models.

UNIT-II

Modeling Thermal Equipments: Modeling heat exchangers, evaporators, condensers, absorption and rectification columns, compressor, pumps, simulation studies, information flow diagram, solution procedures.

UNIT-III

Systems Optimization: Objective function formulation, constraint equations, mathematical formulation, calculus method, dynamic programming, geometric programming, linear programming methods, solution procedures.

UNIT-IV

Dynamic Behavior of Thermal System: Steady state simulation, Laplace transformation, feedback control loops, stability analysis, non-linearties**.**

Optimization: Problem formulation for optimization, optimization methods, optimization of thermal systems, practical aspect in optimal design, Lagrange multipliers, optimization of constrained and unconstrained problems

Reference/Text Books:.

Hodge, B.K. and Taylor, R. P., "Analysis and Design of Energy Systems", Prentice Hall (1999).
Bejan, A., Tsatsaronis, G. and Michel, M., "Thermal Design and Optimization", John Wiley and Sons (1996).
Jaluria, Y., "Design and Optimization of Thermal Systems", McGraw-Hill (1998).
Jaluria, Y., "Design and Optimization of Thermal Systems", CRC Press (2008).
5. Ishigai S., "Steam Power Engineering Thermal and Hydraulic Design Principle", Cambridge University Press (1999).

Note: The paper will have a total of NINE questions. Question No. 1, which is compulsory, shall be Short Answer or Objective Type and have contents from the entire syllabus (all Four Units).

All questions will carry equal **weightage of 12 marks**. The student will attempt a total of **FIVE questions,** each of 12 marks. Q. No. 1 is compulsory. The student shall attempt remaining four questions by selecting **only one question from each unit**

Open Elective

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-III

MTOE-309	BUSINESS ANALYTICS						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
3	-	-	3	60	40	100	3
Objective	The main objective of this course is to give the student a comprehensive understanding of business analytics methods.						
Course Outcomes							
CO1	Able to have knowledge of various business analysis techniques.						
CO2	Learn the requirement specification and transforming the requirement into different models.						
CO3	Learn the requirement representation and managing requirement assests.						
CO4	Learn the Recent Trends in Embedded and collaborative business						

Unit-I

Business Analysis: Overview of Business Analysis, Overview of Requirements, Role of the Business Analyst.

Stakeholders: the project team, management, and the front line, Handling, Stakeholder Conflicts.

Life Cycles: Systems Development Life Cycles, Project Life Cycles, Product Life Cycles, Requirement Life Cycles.

Unit-II

Forming Requirements: Overview of Requirements Attributes of Good Requirements, Types of Requirements, Requirement Sources, Gathering Requirements from Stakeholders, Common Requirements Documents.

Transforming Requirements: Stakeholder Needs Analysis, Decomposition Analysis, Additive/Subtractive Analysis, Gap Analysis, Notations (UML & BPMN), Flowcharts, Swim Lane Flowcharts, Entity-Relationship Diagrams, State-Transition Diagrams, Data Flow Diagrams, Use Case Modeling, Business Process Modeling

Unit-III

Finalizing Requirements: Presenting Requirements, Socializing Requirements and Gaining Acceptance, Prioritizing Requirements.

Managing Requirements Assets: Change Control, Requirements Tools

Unit-IV

Recent Trends in: Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data Journalism.

Reference/Text Books:

1. James Cadle, “Business Analysis”, BCS, The Chartered Institute for IT
2. Erik Larson and, Clifford Gray, “Project Management: The Managerial Process”, McGraw-Hill Education

Note: The paper will have a total of NINE questions. Question No. 1, which is compulsory, shall be Short Answer or Objective Type and have contents from the entire syllabus (all Four Units).

All questions will carry equal **weightage of 12 marks**. The student will attempt a total of **FIVE questions,** each of 12 marks. Q. No. 1 is compulsory. The student shall attempt remaining four questions by selecting **only one question from each unit**

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-III

MTOE-311	INDUSTRIAL SAFETY						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	-	-	3	60	40	100	3
Objective	**To enable students to aware about the industrial safety.**						
Course Outcomes							
CO1	**Understand the industrial safety.**						
CO2	**Analyze fundamentals of maintenance engineering.**						
CO3	**Understand the wear and corrosion and fault tracing.**						
CO4	**Understanding when to do periodic inceptions and apply the preventing maintenance.**						

Unit-I

Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, washrooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

Unit-II

Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

Unit-III

Fault tracing: Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

Unit-IV

Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

Reference/Text Books:

1. Higgins & Morrow, "Maintenance Engineering Handbook", Da Information Services.

2. H. P. Garg, "Maintenance Engineering", S. Chand and Company.
3. Audels, "Pump-hydraulic Compressors", Mcgraw Hill Publication.
4. Winterkorn, Hans, "Foundation Engineering Handbook", Chapman & Hall London.

Note: The paper will have a total of NINE questions. Question No. 1, which is compulsory, shall be Short Answer or Objective Type and have contents from the entire syllabus (all Four Units).

All questions will carry equal **weightage of 12 marks**. The student will attempt a total of **FIVE questions,** each of 12 marks. Q. No. 1 is compulsory. The student shall attempt remaining four questions by selecting **only one question from each unit**

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-III

MTOE-313	OPERATIONS RESEARCH						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
3	-	-	3	60	40	100	3
Objective	To enable students to aware about the dynamic programming to solve problems of discreet and continuous variables and model the real world problem and simulate it.						
Course Outcomes							
CO1	Students should be able to apply the dynamic programming to solve problems of discreet and continuous variables.						
CO2	Students should be able to apply the concept of non-linear programming						
CO3	Students should be able to carry out sensitivity analysis						
CO4	Student should be able to model the real world problem and simulate it.						

Unit-I

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

Unit-II

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

Unit-III

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

Unit-IV

Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

Reference/Text Books:

1. H.A. Taha, “Operations Research, An Introduction”, PHI, 2008
2. H.M. Wagner, “Principles of Operations Research”, PHI, Delhi, 1982.
3. J.C. Pant, “Introduction to Optimisation: Operations Research”, Jain Brothers, Delhi, 2008
4. Hitler Libermann, “Operations Research”, McGraw Hill Pub. 2009
5. Pannerselvam, “Operations Research”, Prentice Hall of India 2010
6. Harvey M Wagner, “Principles of Operations Research”, Prentice Hall of India 2010

Note: The paper will have a total of NINE questions. Question No. 1, which is compulsory, shall be Short Answer or Objective Type and have contents from the entire syllabus (all Four Units).

All questions will carry equal **weightage of 12 marks**. The student will attempt a total of **FIVE questions,** each of 12 marks. Q. No. 1 is compulsory. The student shall attempt remaining four questions by selecting **only one question from each unit**

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-III

MTOE-315	COST MANAGEMENT OF ENGINEERING PROJECTS						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
3	-	-	3	60	40	100	3
Objective	To enable students to make aware about the cost management for the engineering project and apply cost models the real world projects.						
Course Outcomes							
CO1	Students should be able to learn the strategic cost management process.						
CO2	Students should be able to types of project and project team types						
CO3	Students should be able to carry out Cost Behavior and Profit Planning analysis.						
CO4	Student should be able to learn the quantitative techniques for cost management.						

Unit-I

Introduction and Overview of the Strategic Cost Management Process Cost concepts in decision-making; relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Unit-II

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

Unit-III

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Unit-IV

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

Reference/Text Books:

1. Charles Thomas Horngren, "Cost Accounting a Managerial Emphasis", Prentice Hall of India, New Delhi
2. Charles T. Horngren and George Foster, "Advanced Management Accounting"
3. Robert S Kaplan Anthony A. Alkinson, "Management & Cost Accounting"
4. Ashish K. Bhattacharya, "Principles & Practices of Cost Accounting", A. H. Wheeler publisher

5. N.D. Vohra, “Quantitative Techniques in Management”, Tata McGraw Hill Book Co. Ltd.

Note: The paper will have a total of NINE questions. Question No. 1, which is compulsory, shall be Short Answer or Objective Type and have contents from the entire syllabus (all Four Units).

All questions will carry equal **weightage of 12 marks**. The student will attempt a total of **FIVE questions,** each of 12 marks. Q. No. 1 is compulsory. The student shall attempt remaining four questions by selecting **only one question from each unit**

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-III

MTOE-317	COMPOSITE MATERIALS						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
3	-	-	3	60	40	100	3
Objective	To enable students to be aware about the composite materials and their properties.						
Course Outcomes							
CO1	Students should be able to learn the Classification and characteristics of Composite materials.						
CO2	Students should be able reinforcements Composite materials.						
CO3	Students should be able to carry out the preparation of compounds.						
CO4	Student should be able to do the analysis of the composite materials.						

UNIT–I

INTRODUCTION: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

UNIT – II

Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

UNIT–III

Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

UNIT – IV

Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

Reference/Text Books:

1. R.W.Cahn, “Material Science and Technology” VCH, West Germany.
2. WD Callister, Jr, “Materials Science and Engineering, An introduction”
3. Balasubramaniam, “John Wiley & Sons”, NY, Indian edition, 2007.
4. Lubin, “Hand Book of Composite Materials”
5. K.K.Chawla, “Composite Materials”
6. Deborah D.L. Chung, “Composite Materials Science and Applications”

7. Danial Gay, Suong V. Hoa, and Stephen W. Tasi, “Composite Materials Design and Applications”

Note: The paper will have a total of NINE questions. Question No. 1, which is compulsory, shall be Short Answer or Objective Type and have contents from the entire syllabus (all Four Units).

All questions will carry equal **weightage of 12 marks**. The student will attempt a total of **FIVE questions,** each of 12 marks. Q. No. 1 is compulsory. The student shall attempt remaining four questions by selecting **only one question from each unit**

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-III

MTOE-319	WASTE TO ENERGY						
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Total	Time (Hrs.)
3	-	-	3	60	40	100	3
Objective	To enable students to be aware about the generation of energy from the waste.						
Course Outcomes							
CO1	Students should be able to learn the Classification of waste as a fuel.						
CO2	Students should be able to learn the Manufacture of charcoal.						
CO3	Students should be able to carry out the designing of gasifiers and biomass stoves.						
CO4	Student should be able to learn the Biogas plant technology.						

Unit-I

Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

Unit-II

Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

Unit-III

Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

Unit-IV

Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

Reference/Text Books:

1. Desai, Ashok V, “Non-Conventional Energy”, Wiley Eastern Ltd., 1990.
2. Khandelwal, K. C. and Mahdi, S. S., “Biogas Technology - A Practical Hand Book - Vol. I & II”, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Challal, D. S, “Food, Feed and Fuel from Biomass”, IBH Publishing Co. Pvt. Ltd., 1991.
4. C. Y. WereKo-Brobby and E. B. Hagan, “Biomass Conversion and Technology”, John Wiley & Sons, 1996.

Note: The paper will have a total of NINE questions. Question No. 1, which is compulsory, shall be Short Answer or Objective Type and have contents from the entire syllabus (all Four Units).

All questions will carry equal **weightage of 12 marks**. The student will attempt a total of **FIVE questions,** each of 12 marks. Q. No. 1 is compulsory. The student shall attempt remaining four questions by selecting **only one question from each unit**

Fourth Semester

MASTER OF TECHNOLOGY IN MECHANICAL ENGINEERING
(With specialization in Thermal Engineering)
Semester-IV

MTTE-202	DISSERTATION PHASE -II							
Lecture	Tutorial	Practical	Credits	Major Test	Minor Test	Practical Marks	Total	Time (Hrs.)
-	-	32	16	-	100	200	300	-
Objective	The main objective of the course is to make the students to do some good research in the field of their interests related to Thermal Engineering or interrelated fields of applications.							
Course Outcomes								
CO 1	Students will be able to use different experimental techniques or different software/ computational/analytical tools.							
CO 2	Students will be able to design and develop an experimental set up/ equipment/test rig or set up a mathematical model.							
CO 3	Students will be able to conduct tests on existing setups/equipments or simulations and draw logical conclusions from the results after analyzing them.							
CO 4	Students will be able to either work in a research environment or in an industrial environment.							
CO 5	Students will be conversant with technical report writing.							
CO 6	Students will be able to present and convince their topic of study to the engineering community.							

The Students are required to continue Analytical/Experimental/computational investigations in the field of Thermal Engg. or fields related to thermal / advanced topics etc. which have been finalized in the third semester. They would be working under the supervision of a faculty member.

The students will be required to submit a progress report duly signed by their respective supervisors to the department, related to their dissertation work in the last week of March. The progress report will cover the following:

- The goal set for the period.
- Research papers studied.
- Methodology used in achieving the goal.
- The extent of fulfillment of the goal.
- References

The progress report must be at least of 3-4 pages and the cover page should include the tentative topic, name of the candidate, name of the supervisor, period of progress report, signature of candidate and supervisor.

The candidate has to prepare a detailed dissertation report consisting of introduction of the problem, problem statement, literature review, objectives of the work, methodology (experimental set up or numerical details as the case may be) of solution and results and discussion. The report must bring out the conclusions of the work and future scope for the study.

The final dissertation will be submitted in the end of semester as per academic calendar for the session, which will be evaluated by internal as well as external examiners based upon his/her research work. At least one publication is expected before final submission of the dissertation from every student in peer reviewed referred journals or reputed conference from the work done by them in their dissertation. The dissertation should be presented in standard format as provided by the department.

The work has to be presented in front of the examiners panel consisting of an approved external examiner, an internal examiner and a supervisor, co-supervisor etc. as decided by the Head and PG coordinator. The candidate has to be in regular contact with his supervisor.