UNIVERSITY OF CALICUT
(Abstract)

Faculty of Engineering – Regulations, scheme & Syllabi of M.Tech Courses – implemented with effect from 2010 admn onwards - Orders Issued.

GENERAL AND ACADEMIC BRANCH - IV 'E' Section

GAIV/E1/AC / 03.07.2010 Dated, Calicut University.P.O., 27-08-2010.

Read:- 1) U.O. No. GAI/D4/4085/2003 dated, 21.11.2009.
2) Minutes of the meeting of the BOS in Engineering (PG) held on 10.12.2009 and 28.01.2010.
3) Minutes of the meeting of the faculty of Engineering held on 28.01.2010.
4) Minutes of the meeting of the Academic Council held on 03.07.2010.

ORDER

As per paper read 1st, Provisional affiliation was granted to start a new course in M.Tech Machine Design in Nehru College of Engineering & Research Centre, Pampady.

As per the paper read 2nd, the Board of Studies in Engineering (PG) framed, formulated and approved the syllabi of M.Tech in Machine design for 2010-2011. The Board of Studies also framed the revised M.Tech regulations, scheme and Syllabi of the following M.Tech Courses for the year 2010-2011.

1) Environmental Engineering
2) Production Engineering
3) Thermal Systems
4) Power Systems
5) Chemical Process Control
6) Embedded Systems

As per the paper read 3rd, the meeting of the faculty of Engineering approved the decision of the Board of Studies held on 10.12.2009 and 28.01.2010 and approved the revised M.Tech regulations and scheme and syllabi of the above M.Tech Courses.

The faculty also recommended the following in the revised regulations of M.Tech in the case of self financing colleges that there should be sufficient qualified faculty members and sufficient infrastructure in self financing colleges as recommended by All India Council for Technical Education.

As per paper read 4th, the meeting of the Academic Council held on 03.07.2010, approved the decisions of the Board of Studies held on 10.12.2009 and 28.01.2010 and the minutes of the faculty of Engineering held on 28.01.2010 for implementing the regulations and scheme and syllabi of the above M.Tech courses with effect from 2010 admission.

Contd…..2

Sanction has therefore been accorded for implementing the revised M.Tech regulations and Scheme & Syllabi of the following M.Tech Courses with effect from 2010 admission onwards.

1) Environmental Engineering
2) Production Engineering
3) Thermal Systems
4) Power Systems
5) Chemical Process Control
6) Embedded Systems
7) Machine design

Orders are issued accordingly, (regulations, scheme & Syllabi appended)

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UNIVERSITY OF CALICUT

M.Tech. DEGREE COURSE
THERMAL SYSTEMS
(MECHANICAL ENGINEERING)

Curricula, Scheme of Examinations and Syllabi
(with effect from 2010 admissions)

M.Tech. THERMAL SYSTEMS (MECHANICAL ENGINEERING)

CURRICULUM AND SCHEME OF EXAMINATIONS

Semester - I

Code	Subject	Hours per week			Marks		Total Marks	ESE Duration-Hrs	Credits
		L	T	P/D	ICA	ESE			
MTS10 101	Mathematics	3	1	-	100	100	200	3	4
MTS10 102	Advanced Thermodynamics and Combustion	3	1	-	100	100	200	3	4
MTS10 103	Advanced Mechanics of Fluids	3	1	-	100	100	200	3	4
MTS10 104	Advanced Heat and Mass Transfer	3	1	-	100	100	200	3	4
MTS10 105	Elective-I	3	1	-	100	100	200	3	4
MTS10 106(P)	Thermal Systems Lab.		-	2	100	-	100	3	2
MTS10 107(P)	Seminar		-	2	100	-	100		2
	Departmental Assistance		-	6	-	-	-		-
TOTAL		15	5	10			1200		24

Electives -I

MTS10 105(A) Refrigeration Systems
MTS10 105(B) Solar Energy
MTS10 105(C) Nano Technology

Semester - II

Code	Subject	Hours per week			Marks		Total Marks	ESE Duration-Hrs	Credits
		L	T	P/D	ICA	ESE			
MTS10 201	Design of Heat Transfer Equipments	3	1	-	100	100	200	3	4
MTS 10 202	Turbo Machines	3	1	-	100	100	200	3	4
MTS 10 203	Computational Methods in Fluid flow and Heat transfer	3	1	-	100	100	200	3	4
MTS 10 204	Elective-II	3	1	-	100	100	200	3	4
MTS 10	Elective-III	3	1	-	100	100	200	3	4

205									
MTS10 206(P)	Computational Fluid Dynamics Lab		-	2	100	-	100		2
MTS10 207(P)	Seminar		-	2	100	-	100	-	2
	Departmental Assistance		-	6	-	-		-	-
TOTAL		15	5	10			1 200		24

Electives –II

MTS10 204(A) I C Engine Theory and Performance
MTS10 204(B) Experimental Techniques in Thermal and Fluid Engineering
MTS10 204(C) Air Conditioning Systems

Electives –III

MTS10 205(A) Energy Management in Thermal Systems
MTS10 205(B) Propulsion Engineering
MTS10 205(C) Advanced Power Plant Engineering

Semester - III

Code	Subject	Hours per week			Marks		Total Marks	ESE Duration-Hrs	Credits
		L	T	P/D	ICA	ESE			
MTS10 301	Elective-IV	3	1	-	100	100	200	3	4
MTS10 302	Elective-V	3	1	-	100	100	200	3	4
MTS10 303(P)	Industrial Training*			-	-	50	50		1
MTS10 304(P)	Masters Research Project (Phase –I)#			22	Guide 150 / EC 150	-	300		6
TOTAL		6	2	22			750		15

* Industrial training is for a minimum period of two weeks.

Electives –IV

MTS10 301(A) Non Conventional Energy Systems
MTS10 301(B) Optimization Techniques
MTS10 301(C) Cryogenic Engineering

Electives –V

MTS10 302(A) Research Methodology
MTS10 302(B) Advanced Internal Combustion Engine
MTS10 302(C) Finite Element Methods

Semester - IV

Code	Subject	Hours per week			Internal Evaluation		ESE		Total Marks	Credits
		L	T	P/D	Guide	EC	Extl. Guide	Viva-Voce		
MTS10401(P)	Masters Research Project (Phase -II)*	-	-	30	150	150	150	150	600	12
TOTAL				30					600	12

The student has to undertake the departmental work assigned by HOD

Note:
L – Lecture, T – Tutorial, P – Practical, ICA – Internal Continuous Assessment,
ESE – End Semester Examination, EC – Evaluation Committee.

MTS10 101: MATHEMATICS

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: *To enable the students to apply partial differential equations and transformations in Thermal problems.*

Module I (13 hours)

Vector spaces – Basis – Dimensions – Inner product spaces – Gram-Schmidt process– Linear Transformations – Range and Kernel – Isomorphism – Matrix of Transformations and change of Basis**.**

Module II (13 hours)

Power series solutions about ordinary point – Legendre Equation – Legendre Polynomials – Solution about singular points – The method of frobenius – Bessel equation - Bessel functions – Strum-Liouville problem – Generalized Fourier series .

Module III (13 hours)

First order PDE's – Linear equations – Lagrange method – Cauchy method - charpits method – Jacobi method – second order PDE's – Classifications, formulations and method of solutions of wave equation – Heat equation – Laplace equation.

Module IV (13 hours)

Line – Volume – Area integrals – Spaces of N dimensions – Coordinate Transformations– Covariant and mixed tensors – Fundamental operation with Tensors – The line element and metric tensor conjugate Tensor – Christoffel's symbols – Covariant derivative.

REFERENCES:

1. Lay D.C; *Linear Algebra & its Applications*
2. Florey F.G; *Elementary Linear Algebra and its Applications*, Prentice Hall, 1979.
3. Hoffman K & Kunze R; *Linear Algebra*, PHI, 1971
4. Sneddon. I; *Elements of PDE*, Mc Graw-Hill, 1985.
5. Spain B; *Tensor calculus*, 3rd Ed. Oliver & Boyd, 19
6. Ross S.L; *Differential equations*, 3rd Ed. John Wiley.
7. Bell. W.W; *Special Functions for Scientists & Engineers*; Dover
8. C.R.Wylie and L.C.Barrett, *Advanced Engineering Mathematics*. 6th Ed. Mc Graw Hill.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module. All questions carry equal (20) marks.

Module I
Question 1: 20 marks
Question 2: 20 marks
Module II
Question 3: 20 marks
Question 4: 20 marks
Module III
Question 5: 20 marks
Question 6: 20 marks
Module IV
Question 7: 20 marks
Question 8: 20 marks

MTS10 102: ADVANCED THERMODYNAMICS AND COMBUSTION

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: *To impart knowledge on various thermodynamic systems, fuels, combustion systems and estimation of pollutant emission.*

Module I (13 hours)

Introduction to thermodynamics – Equation of states – Properties of gases & gas mixtures – First law of TD – Enthalpy of formation – Heat of reaction – Law of mass action – Fugacity and activity – First law for reaction systems – Second law analysis for reaction systems– Chemical Energy– Stoichiometric & Equivalence ratio – Adiabatic flame temperature

Module II (13 hours)

Second law of TD – Concept of chemical equilibrium – Gibbs free energy and equilibrium constant of a chemical reaction – Vant Hoff's equation - Calculation of equilibrium composition of a chemical reaction

Module III (13 hours)

Fuels and combustion – Classification of fuels (Detailed) – Basic chemistry- Combustion equations- theoretical & Excess air – Stoichiometric Air – fuel – ratio (A/F) – Air fuel ratio from analysis of products – Analysis of exhaust & flue gases – Calorific value of fuels– Determination of calorific values of solids liquid & gaseous fuels – Actual combustion analysis.

Module IV (13 hours)

Combustion systems – Modelling – Well stirred & plug flow model – Laminar- turbulent premixed flows – Determination of flow velocity & length– correlations- Flammability limits – uses in gas burner design – Burning of fuel jets – Liquid droplets and sprays– Combustion in fluidized beds – Estimation of pollutant Emission (CO, NO_x, unburned HC) – Emission indices and control measures.

REFERENCES:

1. P K Nag, *Engineering Thermodynamics*, Tata Mc Graw-Hill 2003

2. M. Achuthan, *Engineering Thermodynamics*, PHI 2002

3. Sharma & Chandramohan, *Fuels and Combustion*, Tata Mc Graw-Hill, 1984

4. Yunus A Cengel, *Thermodynamics*, Tata Mc Graw-Hill 2003 4th Edition.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module. All questions carry equal (20) marks.

Module I
Question 1: 20 marks
Question 2: 20 marks
Module II
Question 3: 20 marks
Question 4: 20 marks
Module III
Question 5: 20 marks
Question 6: 20 marks
Module IV
Question 7: 20 marks
Question 8: 20 marks

MTS10 103: ADVANCED MECHANICS OF FLUIDS

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: *To provide knowledge properties of fluid, basic equations in fluid mechanics, fluid statics, fluid kinematics and some exact solutions of the Navier-Stoke's equations.*

Module I (13 hours)

Basic equations of fluid flow – Reynolds transport equation – Integral and differential formulations – Integral form of equations of continuity – Momentum and energy equations – Use of integral equations – differential form of these equations – Stoke's postulates and

constitutive equations – Navier Stoke's equations and energy equations for Newtonian fluids – Non dimensionalization of the equations of motion and order of magnitude analysis – Identification of non dimensional parameters – Classification of flows based on characteristic Reynolds number– Approximate equations for low Re and high Re flows and boundary layer equations– Boundary conditions

Module II (13 hours)

Some exact solutions of the Navier – Stoke's equations – Couette flows – Plane Poisseuille flow – flow between rotating cylinders – Stoke's first and second problems - Similarity solutions – Fully developed flow through circular and non circular pipes – Approximate solutions – Creeping flow past a sphere – Theory of hydrodynamic lubrication – Boundary layer on flat plate – Blassius solution and use of momentum integral equations

Module III (13 hours)

Waves in supersonic flow – Weak oblique shock – Prandtl- Meyer function – Reflection and intersection of shocks – Thin air - foil theory. Methods of measurements: Shadow methods, Schellerien system – Interferometer

Module IV (13 hours)

Small perturbation theory – Similarity rules of high-speed flow, Transonic flow, Hypersonic flow, and High temperature flows – Basic concepts – Properties of high temperature gases.

TEXT/REFERENCES:

1. S.M. Yahya, *Fundamentals of Compressible Flow*, New Age 1998
2. A.H. Shapiro, *The Dynamics and Thermodynamics of Compressible fluid flow*, Ronald, 1953.
3. Zuckrow M J and Hoffman D J, *Gas Dynamics* , John Wiley & Sons 1975
4. Mularidhar K and Biswas G , *Advanced Engineering Fluid mechanics*,
5. Radhakrishnan E, *Gas Dynamics*, PHI 1995
6. Gupta V and Gupta S, Fluid *Mechanics and its Applications*, Wiley Easter Limited, 1984.
7. White F M, *Viscous fluid flow*, Mc Graw Hill 1999.
8. J.M. Robertson, *Hydrodynamics in Theory and Applications*, Prentice Hall, 1965
9. Pijush K Kundu and Ira M Cohen, *Fluid Mechanics*, Edition 2, Elsvier Academic Press

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module. All questions carry equal (20) marks.

Module I
Question 1: 20 marks

Question 2: 20 marks
Module II
Question 3: 20 marks
Question 4: 20 marks

Module III
Question 5: 20 marks
Question 6: 20 marks
Module IV
Question 7: 20 marks
Question 8: 20 marks

MTS10 104: ADVANCED HEAT AND MASS TRANSFER

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives*: To enable the students to grasp the principles of Heat and Mass transfer and to apply them to design, analysis and further development of various heat and mass transfer systems/applications.*

Module I (13 hours)

General heat conduction equation in Cartesian, cylindrical and spherical co-ordinates – Composite geometries – Variable thermal conductivity – Uniform heat generation- Extended surfaces - Two and three dimensional heat conduction –Numerical and analytical methods.
Unsteady heat conduction – Lumped heat systems – Infinite and semi- infinite bodies – Numerical and analytical methods – Periodic variation of surface temperature – Moving boundaries.

Module II (13 hours)

Convective heat transfer – Boundary layers – Continuity, momentum and energy equations - Boundary layers equations – Dimensional analysis - Exact and approximate solutions to forced convection in laminar and turbulent, internal and external flow – Reynolds and Colburn analogies – forced convection correlations – Solution to free convection problems - Heat transfer at high velocity and incompressible fluid - Liquid metal heat transfer.

Module III (13 hours)

Radiation heat transfer – Basic laws of radiations – Emissive power – Stefan – Boltzmann, Lambert's, Wien's and Kirchhoff's laws – Emissivity – Radiation intensity -
Radiative exchange between black isothermal surfaces, diffuse grey surfaces - Reflecting surfaces – Radiation shape factor - Shape factor algebra – Radiation shields – Combined convective and radiation – Electrical net work analogy solution – Radiosity – Solar radiation – Radiation from gases and vapours.

Module IV (13 hours)

Heat transfer with phase change – Boiling and Condensation – Flow boiling – Correlations.
Mass Transfer – Concentration, velocities, Mass fluxes Fick's law – Species – Conservation equation – Steady state molecular diffusion, Equimolar counter diffusion, diffusion through a stagnant gas film – Chemical reaction.
Convective mass transfer – Concentration boundary layer – Momentum, mass and heat transfer analogy – Convective mass transfer numbers – Flow over flat plates, flow through tubes – Correlations – Evaporation of water into air – Heat and mass transfer in separated flows.

REFERNCES:

1. Arpaci, V.S., *Conduction Heat Transfer,* Addison Wesley, 1966.
2. E.R.G. Eckert and R.M. Drake, *Analysis of Heat Transfer,* McGraw Hill, 1972.
3. E.M. Sparrow, R.D. Cess, *Radiative* Heat Transfer, McGraw Hill, 1972.
4. Holman. J.P, *Heat Transfer,* McGraw Hill.
5. R.C. Sachdeva, *Fundamental of Engineering. Heat and Mass Transfer,* New age International, 2003.
6. Bird R.B and J.R. Howell, *Transport Phenomena,* Wiley International, 1960.
7. Patrico Oostiuson, *Convective heat and Mass Transfer,* McGraw Hill
8. Frank P Incropera and David P Dewitt, *Fundamentals of Heat and Mass Transfer,* John Wiley, 6th Edition 1998
9. Adsian Bejan, *Convective Heat Transfer,* Wiley and Sons.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module. All questions carry equal (20) marks.

Module I
Question 1: 20 marks
Question 2: 20 marks
Module II
Question 3: 20 marks
Question 4: 20 marks
Module III
Question 5: 20 marks
Question 6: 20 marks
Module IV
Question 7: 20 marks
Question 8: 20 marks

MTS10 105(A): REFRIGERATION SYSTEMS

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: *To impart knowledge on advancements in Refrigeration, vapour compression refrigeration systems and its components and characteristics of refrigerants.*

Module I (13 hours)

Recapitulation of thermodynamics - Different methods of refrigeration - Multi pressure systems -Flash gas removal - Multi evaporator systems - Compound refrigeration systems - Multi evaporator and multi compressor systems - Low temperature refrigeration - Cascade systems.

Module II (13 hours)

Thermal compression against mechanical compression - Vapour absorption refrigeration systems - Maximum COP - Common refrigerant absorbent systems - Modification to simple vapour absorption systems - Using liquid-liquid heat exchanger - Using analyzer - Actual vapour absorption systems - and its representation on enthalpy composition diagram - Absorption system calculations - Lithium bromide water systems.

Module III (13 hours)

Vapour compression systems - Limitations of reversed Carnot cycle with vapour as refrigerant -Vapour compression cycle - Enthalpy pressure diagrams - Ewing's construction - Suction cycle for maximum COP - Standard rating cycle and effect of operating conditions - Effect of evaporator pressure - Condenser pressure-suction vapour superheat - Liquid sub cooling -using liquid vapour regenerative heat exchanger - Actual vapour compression system - Complete vapour compression system.

Module IV (13 hours)

Refrigerants - Classification-designation of refrigerants - selection criterion - Thermodynamic requirements - Chemical-physical requirements - Secondary refrigerants - Lubrication in refrigeration system - Non conventional refrigeration systems – Thermo electric - Pulse tube -Vortex tube refrigeration systems - Ejector compression systems - Air refrigeration systems.

REFERENCES:

1. C.P. Arora, *Refrigeration and Air conditioning*, Tata Mc Graw Hill, 2000.
2. Wilbert F. Stoecker, *Refrigeration and Air conditioning*, Mc Graw Hill, Inc 1982.
3. Roy. J Dossat, *Refrigeration and Air conditioning*
4. P.N Anantha Narayanan, *Basic Refrigeration & Air-conditioning*, Tata Mc Graw Hill 1996.
5. Manohar Prasad, *Refrigeration and Air conditioning*, New Age 1999.
6. Carriers Handbook system Design of Air Conditioning.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module. All questions carry equal (20) marks.

Module I
Question 1: 20 marks
Question 2: 20 marks
Module II
Question 3: 20 marks
Question 4: 20 marks
Module III
Question 5: 20 marks
Question 6: 20 marks
Module IV
Question 7: 20 marks
Question 8: 20 marks

MTS10 105 (B): SOLAR ENERGY

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: *To impart the knowledge on solar radiation, photovoltaic solar cell, design of solar thermal systems and solar chargeable battery.*

Module I (13 hours)

Solar Radiation:- Availability - Measurement and Estimation - Isotropic and an Isotropic Models - Introduction to Solar Collectors (Liquid Flat - Plate Collector, Air Heater and Concentrating Collector) and Thermal Storage - Steady State Transient Analysis - Solar Pond - Solar Refrigeration

Module II (13 hours)

Modelling of Solar Thermal Systems and Simulations in Process Design - Design of Active Systems by f-chart and Utilizability Methods - Water Heating Systems - Active and Passive - Passive Heating and Cooling of Buildings - Solar Distillation - Solar Drying

Module III (13 hours)

PHOTOVOLTAIC SOLAR CELL:- P:N Junction - Metal - Schottky Junction, Electrolyte-Semiconductor Junction, Types of Solar Cells - their Applications - Experimental Techniques to determine the Characteristics of Solar Cells

Module IV (13 hours)

Photovoltaic Hybrid Systems - Photovoltaic Thermal Systems- Storage Battery - Solar Array and their Characteristics Evaluation - Solar Chargeable Battery.

TEXT/REFERENCES:

1. S.P. Sukhatme, *Solar Energy: Principles of Thermal Collection and Storage*, Tata McGraw-Hill (1984).
2. J.A. Duffie and W.A. Beckman, *Solar Engineering of Thermal Processes*, John Wiley (1991).
3. J.F. Kreider and F. Kreith, *Solar Energy Handbook* McGraw-Hill (1981).

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module. All questions carry equal (20) marks.

Module I
Question 1: 20 marks
Question 2: 20 marks
Module II
Question 3: 20 marks
Question 4: 20 marks
Module III
Question 5: 20 marks
Question 6: 20 marks
Module IV
Question 7: 20 marks
Question 8: 20 marks

MTS 10 105 (C): NANOTECHNOLOGY

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: *To understand the concept of nanotechnology, nanomaterials3 characterization of nano particles and emerging application of nano materials.*

Module I (13 hours)

Introduction to nano technology –Thermodynamics of Nano Materials and Systems-Hess' Law – Entropy and Criterion for Equilibrium – Statistical interpretation of entropy – Boltzmann equation. Auxiliary Functions – Maxwell's Equations – Gibbs -Helmholtz Equation – First, second, and third laws of thermodynamics as applied to nanoscale systems – Phase Equilibrium – Thermodynamics and kinetics of phase transformations – Homogeneous nucleation – Heterogeneous nucleation – Growth and overall transformation rate – Physical phenomena of small systems – nano-crystals, macromolecules, thermodynamics and physical properties of long chain molecules and molecular structures.

Module II (13 hours)

Nanosized Structures – Design principles and implementation of nano – Engineered materials in the development of nano technology applications. Novel structural functionality, sensory functionality, and information processing capabilities of nanomaterials. Molecular self – Assembly phenomena, emerging hybrid material – System integration protocols.

Module III (13 hours)

Advanced topics in molecular materials and architectures; Nanoscale materials characterization, modeling, analysis, and metrology. Physical properties of nano-structured semiconductors critical to nanoscale optoelectronic devices.

Module IV (13 hours)

Experimental Techniques in Nanotechnology – Statistical principles for design-of-experiment methods as applied to nanomaterials Elementary ideas of blocking, general principles of linear model analysis. Experimental techniques for temperature measurement – Characterization techniques in nanotechnology – Microscopy – Spectroscopic Methods.

REFERENCES:

1. David V. Ragone, *Thermodynamics of Materials, Volume I,* J. W. Wiley 1995.
2. Robert T. DeHoff, *Thermodynamics in Materials Science,* McGraw-Hill, 1993.
3. Y.K. Rao, *Stoichiometry and Thermodynamic Computations in Metallurgical Processes,* Cambridge University Press, 1985.
4. Robert K, Ian H, Mark G, *Nanoscale Science and Technology,* John Wiley & Sons, Ltd.,2005

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module. All questions carry equal (20) marks.

Module I
Question 1: 20 marks
Question 2: 20 marks
Module II
Question 3: 20 marks
Question 4: 20 marks
Module III
Question 5: 20 marks
Question 6: 20 marks
Module IV
Question 7: 20 marks
Question 8: 20 marks

MTS 10 106 (P): THERMAL SYSTEMS LAB

Teaching scheme: 2 hours practical per week **Credits: 2**

Objective: *To familiarize students to the application/practical side of the theories and principles of thermal sciences so as to enable them to design, analyze and take up development activities of similar systems /allied applications.*

- Free Convection Heat Transfer
- Forced Convection Heat Transfer
- Measuring Instruments for R & AC applications
- Performance and emission measurements in two-and-four-stroke S.I. engines
- Performance and emission measurements in Diesel engines
- Performance test on a Centrifugal Pump
- Performance test on a Hydro-turbine
- Measurement of density and Viscosity of oils
- Radiation Heat Transfer
- Boiling Heat Transfer
- Performance evaluation of vapour compression refrigeration
- Measurement and Analysis of combustion parameters in I.C. engines
- Cavitation test on a centrifugal pump
- Evaluation of the Calorific value of gaseous and liquid fuels

TEXTS/REFERENCES:

1. Gabriel D. Roy, Propulsion Combustion, *Fuels to Emission, Taylor & Francis*, Washington D.C 1998.
2. C. Crowe, M. Sommerfeld and Y. Tsuji, *Multiphase Flows with Droplets and Particles, CRC Press*, New York 1998.
3. E.R.G.Eckert and R.J.Goldstein, *Measurements in Heat Transfer, Hemisphere Publishing Corporation*, New York 1976.
4. Benedict R. P, *Fundamentals of Temperature, Pressure and Flow Measurements*, John Wiley & Sons, New York, 1969.
5. J.P.Holman, *Experimental Methods for Engineers*, McGraw Hill Inc., USA, 1994.

Internal Continuous Assessment *(Maximum Marks-100)*

Regularity	30%
Record	20%

Test/s, Viva-voce 50%

MTS10 107(P): SEMINAR

Teaching scheme: 2 hours per week **Credits:** 2

Objective: *To assess the debating capability of the student to present a technical topic. Also to impart training to a student to face audience and present his ideas and thus creating in him self esteem and courage that are essential for an engineer.*

Individual students are required to choose a topic of their interest from Thermal Engineering related topics preferably from outside the M.Tech syllabus and give a seminar on that topic about 30 minutes. A committee consisting of at least three faculty members (preferably specialized in Thermal Engineering) shall assess the presentation of the seminar and award marks to the students. Each student shall submit two copies of a write up of his / her seminar topic. One copy shall be returned to the student after duly certifying it by the Chairman of the assessing committee and the other will be kept in the departmental library. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation.

Internal continuous assessment: 100 marks

Evaluation shall be based on the following pattern:

Report	=	50 marks
Concept/knowledge in the topic	=	20 marks
Presentation	=	30 marks
Total marks	=	100 marks

MTS10 201: DESIGN OF HEAT TRANSFER EQUIPMENTS

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objective: *To impart knowledge on theory and constructional details of various types heat exchangers and their design aspects.*

Module I (12 hours)

Double Pipe Heat Exchangers - Film Coefficients of Fluids and Tubes - Equivalent diameter for fluids flowing in Annuli - Film coefficients for fluids in Annuli: Fouling factors - The Caloric or Average Fluid Temperature - Heat load - LMTD and NTU methods of evaluation of heat exchangers - The calculation of double pipe exchanger: Double pipe exchangers in series - parallel arrangements.

Module II (13 hours)

Shell and Tube heat exchangers - Tube layouts for exchangers- Baffle spacing, different types of shell and tube exchangers - The calculations of shell and tube exchangers shell side film coefficients - shell side equivalent diameter - The true temperature difference in a 1-2 exchanger. Influence of approach temperature on correction factory - Shell- side pressure drop - Tube side pressure drop- Analysis of performance of 1-2 exchangers and design calculation of shell and tube heat exchangers - Flow arrangements for increased heat recovery - The calculations of 2-4 exchangers - TEMA standards.

Module III (13 hours)

Direct-contact heat exchanger: cooling towers relation between the wet-bulb and dew point temperatures - The Lewis number - Classification of cooling towers cooling-tower internals and the role of fill - Heat exchange heat transfer by simultaneous diffusion and convection - Analysis of cooling towers measurements - Design of cooling towers - Determination of the number of diffusion units - Calculation of cooling tower performance - The influence of process conditions upon design - The influence of operation tables.

Module IV (14 hours)

Heat pipes types and applications - Heat pipe operating principle - Working fluid - Wick selection and wick structures – Compatibility – Limitations - Design of circular heat pipes.

TEXTS/REFERENCES:

1. Donald Q.Kern, *Process Heat Transfer,* Tata Mc Graw-hill Publishing Company, Ltd.,
2. Hewitt, Shires and Bolt, *Process Heat transfer,* CRC Press
3. A.P.Frans and M.N.Ozisik, *Heat exchanger Design,* John Wiley & Sons New York
4. P.Dunn and D.A.Reay , *Heat Pipes,* Pergamom Press
5. G.P.Peterson, *Design of Heat Pipes*.
6. Kam.W.Li and A. Paul Priddy, *Power Plant System Design*, John Wiley & Sons Inc.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module. All questions carry equal (20) marks.

Module I
Question 1: 20 marks
Question 2: 20 marks
Module II
Question 3: 20 marks
Question 4: 20 marks
Module III
Question 5: 20 marks
Question 6: 20 marks
Module IV
Question 7: 20 marks
Question 8: 20 marks

MTS10 202: TURBOMACHINES

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objective: *To familiarize the students to the principles and operations of Turbo-machines so as to enable them to take up the Design, analysis and development of such systems.*

Module I (13 hours)

Equation of motion in Cartesian and cylindrical co-ordinates – Absolute potential flow – Potential and stream functions – Vorticity, circulation, rotational and irrotational flows – Two and three dimensional flows in turbo-machines.

Flow through cascade of blades, Annular, radial and compressor and turbine cascades – Cascade tunnel – Cascade performance, variables and losses – Blade forces – Performance parameters of compressible machines.

Module II (13 hours)

Incompressible fluid machines – Theory of centrifugal pumps – Ideal torque equation – pressure rise – Circulatory flow – Effect of blade angle, number of blade, speed and diameter – Losses – Cavitation, NPSH, Surging. Design of radial stage impeller – Simple curvature blades – Design of volutes and diffusers – Francis type impeller – Blade twist.

Axial flow pumps – Experimental design factors – Aerofoil theory of design.

Module III (13 hours)

Centrifugal fans and blowers – Compressibility – Stage parameters – Volutes and diffusers – Losses – Design parameters – Design calculations for impeller, volute and diffusers.

Centrifugal compressors – stage velocity triangles – Blade shapes – Enthalpy –entropy diagrams – Analysis of flow in impeller and diffuser – slip factor – stage losses – Degree of reaction – Performance characteristics – Surging and choking – Multistage compressors.

Module IV (13 hours)

Axial flow compressors – velocity triangles - Enthalpy –entropy diagrams – Blade loading, stage losses and efficiencies – Degree of reaction – Varying reaction stage – Flow through rotor and stator blade rows – Work done factor – Radial equilibrium – supersonic and transonic stages – Performance characteristics of design operation – Surging and stalling.

Axial and radial flow turbines – Stage velocity triangles – Velocity and pressure compounding – reaction stages – Losses and efficiencies – Performance characteristics – Manufacture of blades – Blade fixing – High temperature cooled turbines – Blade cooling.

TEXTS/REFERENCES:

1. D.G. Sheperd, *Principles of turbo machinery*, The Macmillan Company, New York.
2. A. H. Church and Jagadish Lal, *Centrifugal Pumps and Blowers*, Metropolitan Book Co. 1973
3. A.J. Stepanoff, *Centrifugal and Axial Flow Pumps*, Wiley & sons, 1966.

4. J.H. Horlock, *Axial Flow Compressors*, Butterworths Scientific Publications, 1958.
5. S.M. Yahya, *Turbine, Compressors and Fans*, Tata McGraw Hill Co. New Delhi, 1998.
6. V. Ganesan, *Gas Turbines*, Tata McGraw Hill Co. New Delhi, 2001.
7. Khajuria and Dubey, *Gas Turbines and Propulsive Systems*, Dhanpatrai Pub.
8. M.H.Vavra, *Aerothermodynamics and Flow in Turbomachines.*

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module. All questions carry equal (20) marks.

Module I
Question 1: 20 marks
Question 2: 20 marks
Module II
Question 3: 20 marks
Question 4: 20 marks
Module III
Question 5: 20 marks
Question 6: 20 marks
Module IV
Question 7: 20 marks
Question 8: 20 marks

MTS10 203: COMPUTATIONAL METHODS IN FLUID FLOW AND HEAT TRANSFER

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objective: *To impart knowledge on Computational Fluid Dynamics using Finite Difference method and Finite Volume Method.*

Module I (12 hours)

Comparison of experimental, theoretical and numerical approaches: Partial differential equations - Physical and mathematical classification - Parabolic, Elliptical and Hyperbolic equations. Computational economy, Numerical stability, Selection of numerical methods, validation of numerical results: Numerical error and accuracy – Round off error, accuracy of numerical results – Iterative convergence – Condition for convergence, Rate of convergence, under-relaxation and over relaxation, Termination of iteration: Tridiagonal Matrix algorithm. Finite Difference method: Discretization – Converting Derivatives to discrete Algebraic Expressions, Taylor's series approach, polynomial fitting approach, Discretization error.

Module II (12 hours)

Heat conduction – Steady one-dimensional conduction in Cartesian and cylindrical co-ordinates, handling of boundary conditions: Two dimensional steady state conduction problems in Cartesian and cylindrical co-ordinates – point by point and line by line method of

solution: Dealing of Dirichlet, Neumann and Robbins type boundary conditions- Formation of discretized equations for regular boundaries, irregular boundaries and interfaces.

Module III (14 hours)

One dimensional, two dimensional and three dimensional transient heat conduction problems in Cartesian and cylindrical co-ordinates- Explicit, Implicit, Crank Nicholson and ADI methods- stability of each system- Conservation form and conservative property of partial differential equations and finite difference equations-Consistency, stability and convergence for marching problems-Discrete perturbation stability analysis- Fourier or Von Neumann stability analysis.

Module IV (14 hours)

Finite volume method: Discretization of governing equations - Diffusion and convection-diffusion problems- steady one-dimensional convection and diffusion, upwind, hybrid and power-law schemes: Discretization equation for two-dimensions: False diffusion, calculation for the Flow-Field- Stream function- vorticity approach, SIMPLE, SIMPLER, SIMPLEC and QUICK Algorithms. Numerical Marching Techniques. Two dimensional parabolic flows with heat; Grid generation methods, Adaptive grids.

Computer assignments on fluid flow and heat transfer problems essential as part of session requirements.

REFERENCES:

1. John D Anderson Jr , *Computational Fluid Dynamics*, McGraw Hill
2. H.K Versteeg and W Malalasekera, *An Introduction to Computational Fluid Dynamics*,
3. S.V. Patankar Hemisphere, *Numerical Fluid Flow & Heat transfer*
4. Hoffman Klaus Vol-1 & 2 *Computational Fluid Dynamics*
5. T. Sundernajan- Narosa, *Computational Fluid Flow and Heat Transfer*
6. D.A.Anderson, J.C.Tannehill and R.H.Fletcher, *Computational Fluid Flow and Heat Transfer*

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module. All questions carry equal (20) marks.

Module I
Question 1: 20 marks
Question 2: 20 marks
Module II
Question 3: 20 marks
Question 4: 20 marks
Module III
Question 5: 20 marks
Question 6: 20 marks

Module IV
Question 7: 20 marks
Question 8: 20 marks

MTS10 204(A): IC ENGINE THEORY AND PERFORMANCE

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: *To impart knowledge on the theory of combustion, alternative fuel, recent trends in IC Engines and its performance.*

Module I (13 hours)

Spark Ignition Engines, mixture requirements – Fuel – Injection systems– Monopoint, Multipoint injection, Direct injection – Stages of combustion – Normal and abnormal combustion – Factors affecting knock – Combustion chambers.

Module II (13 hours)

Compression ignition engines, Stages of combustion in C.I. Engine – Direct and indirect injection systems – Combustion chambers – Fuel spray behaviour – spray structure, spray penetration and evaporation – Air motion – Introduction to Turbo charging and supercharging

Module III (13 hours)

Alternative fuels, Alcohol, Hydrogen, Natural Gas Bio diesel, fuel cell. Other possible fuels and Liquefied Petroleum Gas- Properties, Suitability, Merits and Demerits as fuels, Engine Modifications. Dual fuel operation

Module IV (13 hours)

Recent trends, Lean Burn Engines – Stratified charge Engines – homogeneous charge compression ignition engines – Plasma Ignition – Zero Emission Vehicles, Engines for special applications – Mining, Defence, Off-highway -Tractor, Bulldozer etc. Submarines, Race car Engine systems, Flexible fuel systems. Surface ignition,

REFERENCES:

1. K.K. Ramalingam, *Internal Combustion Engine Fundamentals*, Scitech Publications, 2002.
2. John B Heywood, *Internal Combustion Engine Fundamentals*, McGraw Hill
3. M.L. Mathur and R.P.Sharma, *A course in internal Combustion Engines*, Dhanapat Rai Publications, New Delhi.
4. V. Ganesan, *Internal Combustion Engines*, IInd Edition, TMH, 2002.
5. Duffy Smith, *Auto fuel Systems*, The Good Heart Willox Company, Inc.
6. Ganesan V., *Computer simulation of spark ignition process*, University process. Hyderabad 1993.

7. Ganesan V. *Computer simulation of compression ignition engine.*, Orient Long man 2000

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module. All questions carry equal (20) marks.

Module I
Question 1: 20 marks
Question 2: 20 marks
Module II
Question 3: 20 marks
Question 4: 20 marks
Module III
Question 5: 20 marks
Question 6: 20 marks
Module IV
Question 7: 20 marks
Question 8: 20 marks

MTS10 204 (B): EXPERIMENTAL TECHNIQUES IN THERMAL AND FLUID ENGINEERING

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objective*: To impart knowledge on Mechanical measurements in engineering, errors in measurements and signal conditioning.*

Module I (15 hours)

Importance of Experimental investigation – A methodology for experimental investigation. Error, accuracy, reproducibility and uncertainty – Systematic and random errors – Absolute and relative (percentage) errors – Error and propagation formulae – ASME recommended procedure for estimation of error and uncertainty.
Review of Statistical Concepts -Random variable – Normal Distribution – mean & Variance – Point & Interval Estimation – Types of Estimators – Efficient – Unbiased & Maximum – Likelihood Estimates - Tests of Hypotheses- Design of Experiments. One way – Two way classification tests with & without interaction.

Module II (13 hours)

Signal conditioning – operational amplifiers- Non Inverting mode – Inverting mode- Op-amp circuits used in Instrumentation – Differential amplifiers– Instrumentation amplifiers – Attenuators – Amplifier modulation -demodulation- Filters – types– Filters with cascade

sections -AC Bridges – Universal independence Bridge- A-D-A Conversion Techniques – D/A conversion -Integration & Differentiation using R.C Circuits – Clipping Circuits

Module III (12 hours)

Basics concepts in static Measurements – Calibration and standards – Generalized measurements Systems – Basic concepts in Dynamic Measurements.
Pressure measurements – Velocity measurements – Flow measurements – Temperature measurements – Heat flux measurements

Module IV (12 hours)

Measurement of thermal and Transport properties – Force, Torque, Strain – measurements – Vibration measurements – Nuclear and thermal radiation measurements. Writing and presentation of reports.

REFERENCES:

1. Miller & Freund, Richard A Johnson, *Probability and Statistics for Engineers*, 5th Edition.
2. A.K. Sawhney, *A course in Mechanical Measurements and Instrumentation*, Dhanpat Rai, 2000.
3. Doeblin E.O, *Measurement Systems*, Mc Graw Hill 1990.
4. Richard S.Figliola and Donald E. Beasley., *Theory and Design for Mechanical Measurements*, 3rd Edition- John Wiley & Sons Inc.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to student's right at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module. All questions carry equal (20) marks.

Module I
Question 1: 20 marks
Question 2: 20 marks
Module II
Question 3: 20 marks
Question 4: 20 marks
Module III
Question 5: 20 marks
Question 6: 20 marks
Module IV
Question 7: 20 marks
Question 8: 20 marks

MTS10 204 (C): AIR CONDITIONING SYSTEMS

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits**: 4

Objectives: *To impart knowledge on Load estimation, Design of Air conditioning systems, Introduction to waste heat recovery and cogeneration.*

Module I (12 hours)

Thermal comfort - Effective temperature - Comfort chart - Inside design condition - Ventilation standards - Applied psychometry - Summer air conditioning processes, winter air conditioning processes.

Module II (13 hours)

Load estimating - Comfort conditions - Weather data - Solar heat gain - Cooling and heating loads: heat gain/loss through glass - Heat gain/loss through structures – Internal load – Ventilation load - Infiltration load.

Module III (13 hours)

Air distribution: room air distribution - Air diffusion equipments - Friction losses and dynamic losses in ducts- Air duct design.
Air handling equipments: Fans-types, Performance and selection - Air conditioning apparatus -Humidification and dehumidification equipments - Automatic controls - Noise reduction.

Module IV (14 hours)

Air conditioning systems - DX systems-all water systems - All air systems - Air water systems -Central and unitary systems - Fan coil systems
Automatic controls of air conditioning systems - Thermostats dampers and damper motors -automatic valves piping design - Water piping - Refrigerant piping - Steam piping

REFERENCES:

1. Arora and Domkundwar, *Refrigeration and Air Conditioning* - 1993
2. Wilbert F. Stoecker, *Refrigeration and Air conditioning*, Mc Graw Hill, Inc 1982.
3. 1992 ASHRAE HAND BOOK-HVAC systems & equipments
4. Kell J.R, Martin P.L, *Heating and air-conditioning of buildings*, Butterworth
5. Levenhagen, J.L.,Stethmann, D., *heating ventilation and air conditioning controls and systems*, Mc-Graw Hill

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to student's right at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module. All questions carry equal (20) marks.

Module I
Question 1: 20 marks
Question 2: 20 marks
Module II
Question 3: 20 marks
Question 4: 20 marks
Module III
Question 5: 20 marks
Question 6: 20 marks
Module IV
Question 7: 20 marks
Question 8: 20 marks

MTS 10 205 (A): ENERGY MANAGEMENT IN THERMAL SYSTEMS

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: *To provide knowledge on energy conservation schemes, available energy and fuels.*

Module I (13 hours)

Importance of Energy Management. Energy Auditing: Methodology, Analysis of Past Trends (Plant Data), Closing the Energy Balance, Laws of Thermodynamics, Measurements, Portable and on-line instruments.

Module II (13 Hours)

Co-generation Concept, Options (Steam/Gas Turbines /Diesel Engine based), Selection Criteria, Control Strategy , Heat Exchanger Networking Concept of Pinch , Target Setting , Problem table Approach, Composite curves. Demand side Management. Financing Conservation.

Module III (13 Hours)

Energy Conservation in Pumps, Fans (Flow Control), Compressed Air Systems, Refrigeration and Air Conditioning Systems, Waste Heat Recovery: Recuperators, Heat Wheels, Heat Pipes, Heat Pumps.

Module IV (13 hours)

Electrical Systems: Demand Control, Power factor Correction, Load Scheduling / Shifting, Motor Drives - Motor Efficiency Testing, Energy Efficient Motors, Motor Speed Control.

Lighting - Lighting Levels, Efficient Options, Fixtures, Day lighting, Timers, Energy Efficient Windows

TEXT / REFERENCES:

1. Kenny, *Energy Management in Thermal Systems*

2. Reay.D.A , *Industrial Energy Conservation*, Pergamon Press 1977

3. D.Merick and R. Marshall, *Energy Present and Future Options*. Vol I & II

John Wiley & Sons, 1981

4. B. Sorenson, *Renewable Energy*, Academic Press, 1989.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module. All questions carry equal (20) marks.

Module I
Question 1: 20 marks
Question 2: 20 marks
Module II
Question 3: 20 marks
Question 4: 20 marks
Module III
Question 5: 20 marks
Question 6: 20 marks
Module IV
Question 7: 20 marks
Question 8: 20 marks

MTS10 205 (B): PROPULSION ENGINEERING

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objective: *To impart knowledge on theory and practice of gas turbines and jet propulsion so as to enable the students to use them in design,analysis,and development of such systems.*

Module I (13 hours)

Inlets and nozzles - Flow through nozzles - Isentropic and adiabatic flow with friction - Subsonic and supersonic inlets – Diffusers - Exhaust nozzles.
Review of axial and centrifugal compressors - Axial and radial turbines
Combustion systems - Combustion theory, requirements, design factors and performance of combustion chambers - Combustion process in a gas turbine - Mixing and dilution - Combustion chamber arrangements – Supersonic combustion - Burner efficiency - After burners.

Module II (13 hours)

Gas turbines - Open and closed cycles - Requirements of working medium - Applications.
Ideal cycles and their analysis - Simple cycle and its modifications with reheat, regeneration and inter cooling - Ericsson cycle.

Real cycles - Compressor and turbine efficiencies - Heat exchanger effectiveness - Flow losses -Incomplete combustion - Cycle efficiency - Performance prediction of simple gas turbines - Off Design operations - Methods of improving part load operations - Transient behaviour -Performance deterioration.

Module III (13 hours)

Thermodynamics of aircraft jet engines - Jet propulsion and their analysis - Thrust and efficiency -Ram jet, turbo prop, turbo jet engines - Performance-thrust augmentation.
Performance of Rocket vehicles-static performance, vehicle acceleration - Electrical rocket vehicles - Space missions.

Module IV (13 hours)

Chemical Rocket - Thrust Chambers:-Performance Characteristics – Nozzles - Rocket Heat Transfer - Liquid Propellant Rocket Performance - Equilibrium composition - Non equilibrium expansion - Liquid - Propellant combustion chambers - Combustion instabilities.

REFERENCES:

1. Philip G.Hill and Carl R.Peterson, *Mechanics and Thermodynamics of Propulsion*, Second Edition, Addition-Wesley Publishing Company, NewYork, 1992.
2. Cohen, Rogers and Saravanamuttoo, *Gas Turbine Theory,* Pearson Education Pvt. Ltd
3. S.M. Yahya, *Gas Dynamics and Jet Propulsion.*
4. S.M Yahya, *Turbines, compressors and Fans,* Tata Mc-Graw Hill Ltd. New Delhi
5. V.Ganesan, *Gas turbines,* Tata Mc-Graw Hill Pub.co.Ltd. New Delhi.
6. Jack D Mattingly, *Elements of Gas turbine propulsion.* Mc Graw Hill Inc.
7. Bonney E.A. Zucrow N.J. *Principles of Guided Missile Design*, Van Nostrand Co., 1985.
8. Zucrow N.J., *Principles of Jet Propulsion and Gas Turbines,* John Wiley and Sons Inc, New York, 1970.
9. Zucrow N.J., *Aircraft and Missile Propulsion,* Vol.I and Vol.II, John Wiley and Sons Inc, New York, 1975.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module. All questions carry equal (20) marks.

Module I
Question 1: 20 marks
Question 2: 20 marks
Module II
Question 3: 20 marks
Question 4: 20 marks
Module III
Question 5: 20 marks

Question 6: 20 marks
Module IV
Question 7: 20 marks
Question 8: 20 marks

MTS10 205 (C): ADVANCED POWER PLANT ENGINEERING

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objective*: To provide knowledge on advanced steam power plants, boilers, steam nozzles, gas turbines, nuclear power plants and MHD power plants*

Module I (13 hours)

Introduction - Energy reserves and Energy utilization the world - Electrical Power Generation & Consumption in India. Types of Power Plants Merits and Demerits - Criteria for Selection of Power Plants. Steam power plant - Layout -Super Heaters, Reheaters, Condensers Economizers and Feed Water heaters - Operation and performance - Rankine cycle with Super Heat, Reheat and Regeneration - Fluidized Bed combustion boiler – Advantages – Waste heat Recovery boilers - Co-generation Power Plant – Emissions and their controls.

Module II (13 hours)

Nuclear Power Plant:- Overview of Nuclear Power Plant – Nuclear physics Radio activity – fission process Reaction Rates-diffusion theory - Critical heat flux – Nuclear Power Reactors -different types - Advantages and limitations - Materials used for Reactors. Hazards in Nuclear Power Plant – Remedial Measures – Safety precautions – Methods of Waste disposal Different form of Waste from Power Plant.

Module III (13 hours)

Gas Turbine And MHD Power Plant:- Layout of Gas Turbine – Basic Gas turbine cycle – Cycle improvements – Intercoolers, Reheaters and regenerators, Thermodynamic analysis of Gas turbine – Operations and performance of Gas Turbine Layout of MHD Power Plant – Principles of Working – Function and Importance of Individual Component – Salient features.

Module IV (13 hours)

Combined Cycle Power Plant: - Binary vapour cycles-Coupled cycles – Combined Power cycle Plants – Advantages and Limitations, Gas turbine-Steam turbine Power Plant and MHD – Steam Power Plant.

REFERENCES:

1. P. K. Nag, *Power Plant Engineering* , McGraw-Hill
2. M.M. Wakil, *Power Plant Engineering Technology*, McGraw-Hill
3. Everett B.Woodruff Lammers, Thomas F.Lammers, *Steam Plant operation*, McGraw-Hill
4. Thomas C. Elliott, Kao Chen Robert C. Swamekamp, *Standard Hand Book of Power Plant Engineering*, McGraw-Hill.

Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject.

The assessment details are to be announced to student's right at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module. All questions carry equal (20) marks.

Module I
Question 1: 20 marks
Question 2: 20 marks
Module II
Question 3: 20 marks
Question 4: 20 marks
Module III
Question 5: 20 marks
Question 6: 20 marks
Module IV
Question 7: 20 marks
Question 8: 20 marks

MTS 206 (P): COMPUTATIONAL FLUID DYNAMICS LAB

Teaching scheme: 2 hours practical per week **Credits: 2**

- Study on different programming languages and software packages commonly used in engineering such as MATLAB, C++ etc.
- Programs for solving simultaneous linear equations and differential equations
- Exercises on heat conduction, elasticity, fluid flow, fins, cooling of electronic package problems etc. using commercial FEM packages
- Modeling of flow around aero foils using commercial FEM packages
- Exercises on natural and mixed convection problems, laminar/turbulent flows, forced convection problems using commercial CFD solvers.
- Exercises on hydrodynamic and thermal boundary layer problems using commercial CFD solvers.
- Simulation of flow in turbo machines using commercial CFD solvers

Note: General programming shall be carried out preferably using MATLAB.
Internal Continuous Assessment *(Maximum Marks-100)*
Regularity 30%
Record 20%
Test/s, Viva-voce 50%

MTS10 207 (P): SEMINAR

Teaching scheme: 2 hours per week **Credits:** 2

Objectives: *To assess the debating capability of the student to present a technical topic. Also to impart training to a student to face audience and present his ideas and thus creating in him / herself esteem and courage that are essential for an engineer.*

Individual students are required to choose a topic of their interest from Thermal Engineering related topics preferably from outside the M.Tech syllabus and give a seminar on that topic about 30 minutes. A committee consisting of at least three faculty members (preferably specialized in Thermal Engineering) shall assess the presentation of the seminar and award marks to the students. Each student shall submit two copies of a write up of his / her seminar

topic. One copy shall be returned to the student after duly certifying it by the Chairman of the assessing committee and the other will be kept in the departmental library. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation.

Internal continuous assessment: 100 marks

Evaluation shall be based on the following pattern:

Report	=	50 marks
Concept/knowledge in the topic	=	20 marks
Presentation	=	30 marks
Total marks	=	100 marks

MTS10 301 (A): NON CONVENTIONAL ENERGY SYSTEMS

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objective: *To impart knowledge on various Non Conventional Energy Systems and its significance.*

Module I (12 hours)

Introduction - World energy use - Reserves of energy resources-energy cycle of the earth-Environmental aspects of energy utilization - Renewable energy resources and their importance.

Module II (13 hours)

Solar Energy :- Introduction - Extraterrestrial solar radiation - Radiation at ground level -collectors - Solar cells - Applications of solar energy - Biomass Energy – Introduction -Biomass Conversion-Biogas Production-Ethanol Production-Pyrolysis and Gasification -Direct Combustion – Applications.

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Module III (13 hours)

Wind, Geo Thermal And Hydro Energy Sources: - Introduction-basic theory - Types of turbines - Applications - Geothermal Energy-Introduction - geothermal resource types -resource base - Applications for heating and electricity generation - Hydropower -Introduction - Basic concept site selection - Types of turbines - Small scale hydropower.

Module IV (14 hours)

Tidal Energy: - Introduction - Origin of tides - Power generation schemes - Wave Energy -Introduction - Basic theory - Wave power devices - Other renewable energy sources – Introduction - Open and Closed OTEC cycles - bio photolysis - Ocean Currents - Salinity Gradient Devices - Environmental Aspects - Potential impacts of harnessing the different renewable energy resources.

REFERENCES:

1. A. Duffie and W.A. Beckmann, *Solar Engineering of Thermal Processes,* John Wiley 1980.
2. F. Kreith and J.F. Kreider, *Principles of Solar Engineering,* McGraw-Hill 1978.
3. T.N. Veziroglu, *Alternative Energy Sources, Vol. 5 and 6,* McGraw-Hill 1978.

4. S.P.Sukhatme, *Solar Energy Principles of Thermal Collection& Storage*, Tata Mc Graw Hill, 1991

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module. All questions carry equal (20) marks.

Module I
Question 1: 20 marks
Question 2: 20 marks
Module II
Question 3: 20 marks
Question 4: 20 marks
Module III
Question 5: 20 marks
Question 6: 20 marks
Module IV
Question 7: 20 marks
Question 8: 20 marks

MTS10 301 (B): OPTIMIZATION TECHNIQUES

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objective*: To impart knowledge on Linear programming, Non linear programming, Dynamic Programming and Integer linear programming*

Module I (13 hours)

Linear Programming: - Systems of linear equations and inequalities – Convex sets – Convex functions – Formulation of linear programming problems – Theory of simplex method – Simplex algorithm – Big M method – Two Phase method – Duality in linear programming – Dual simplex method.

Module II (13 hours)

Sensitivity analysis – Parametric programming – Bounded variable problems – Transportation problems – Development of the method – Integrality property – Degeneracy – Unbalanced problems – Assignment problems – Development of the Hungarian method – Routing problems.

Module III (13 hours)

Non linear Programming:- Quadratic Programming – Separable convex programming – Frank & Wolfe's method – Kelley's cutting plane method – Rosen's gradient projection method - Fletcher – Reeve's method – Penalty and Barrier methods – Scheduling- 2 jobs M machining – N jobs 2 machining – N jobs 3 Machines Scheduling .

Module IV (13 hours)

Nature of Dynamic programming problem – Bellman's Optimality principle – Replacement problems – Integer linear programming – Gomory's cutting plane method – Branch and Bound Algorithm – Travelling Salesman problem – Knapsack problem – Introduction to Optimization tools and software.

REFERENCES:

1. Taha. H. A., *Operations Research, An Introduction* , Sixth edition PHI.
2. Simmons D. M, *Nonlinear Programming for Operations Research,* PHI
3. M. S. Bazaraa. H. D. Sherali, C. M. Shetty, *Nonlinear programming theory and Algorithm,* John Wiley, II edition, 1993.
4. Hadley G, *Linear Programming,* Addison Wesley.
5. Hillier. F. S. & Lieberman G.J., *Introduction to Operations Research,* McGraw Hill.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module. All questions carry equal (20) marks.

Module I
Question 1: 20 marks
Question 2: 20 marks
Module II
Question 3: 20 marks
Question 4: 20 marks
Module III
Question 5: 20 marks
Question 6: 20 marks
Module IV
Question 7: 20 marks
Question 8: 20 marks

MTS10 301 (C): CRYOGENIC ENGINEERING

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: *To impart knowledge on properties of cryogenic fluid, cycles and cryogenic refrigerators.*

Module I (13 hours)

Gas Liquefaction Systems - Thermodynamically Ideal System, Joule - Thomson Effect, Adiabatic Expansion - Liquefaction Systems for Air, Neon, Hydrogen and Helium - Effect of component efficiencies on System Performance

Module II (13 hours)

Gas Separation and Purification - Principles - Plate Calculations - Air, Hydrogen and Helium separation systems.

Module III (13 hours)

Cryogenic systems - Ideal and practical systems - Cryogenic Fluid Storage and Transfer systems - Storage vessels , Insulation - Two Phase Flow in Cryogenic Transfer Systems - Cool Down Process

Module IV (13 hours)

Cryogenic Fluid Vacuum Technology - Low Temperature Properties of Materials - Properties of Cryogenic Fluids - Pump Down Time - Applications of Cryogenic Systems - Super Conductive Devices , Rockets and Space Simulation, Cryogenics in Biological and Medicine - Cryo pumping

REFERENCES:

1. Randall Baron, *Cryogenic System*, Mc Graw Hill
2. K.D. Timmerhaus & T.M. Flynn, *Cryogenic Process Engineering*, Plenum Press
3. Russel B Scott, *Cryogenic Engineering*, Van Nostrand
4. R W Yance and WM Duke, *Applied Cryogenic Engineering*, John Willey.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module. All questions carry equal (20) marks.

Module I
Question 1: 20 marks
Question 2: 20 marks
Module II
Question 3: 20 marks
Question 4: 20 marks
Module III
Question 5: 20 marks
Question 6: 20 marks
Module IV
Question 7: 20 marks
Question 8: 20 marks

MTS10 302 (A): RESEARCH METHODOLOGY

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: *To understand the different aspects of social and managerial research.*

To understand the approach and methods of managerial research.

Module I (12 hours)

Meaning of research-nature and scope of research — Important applications of Managerial research in decision making — The research process and types of research — Definition of research problem-methods of problem formulation. — Role literature review in formulation of research problem — Research design — Uses and applications — Types of research designs — Exploratory, descriptive, experimental research designs — Administrative structure for management research.

Module II (12 hours)

Population survey and sample study-sampling theories- random sampling and non random sampling — Different methods of random and non random sampling-sample size decisions —factors influencing sample size decision — Optimum sample size — Pilot survey.

Module III (13 hours)

Methods and techniques of data collection — Observation and survey methods — Tools of data collection — Questionnaire and interview schedule — Questionnaire preparation — Attitude measurement — Scaling techniques — Different types of scales — Validity and reliability of scale — Scale values.

Module IV (15 hours)

Field work and data processing — Classification and tabulation – Data summarization — analysis and interpretation of data — Univariate analysis, bivariate analysis, correlation and regression analysis — Testing of hypothesis — Parametric and non parametric tests —

multivariate analysis — Factor analysis, discriminate analysis, conjoint analysis, cluster Analysis — Use of statistical software packages.

Report writing — Types of reports — Substance of report-format of reports — Executive summery — Content of the report — Bibliography — References — Presentation of reports Compulsory case.

REFERENCES:

1. Cooper Donald R and Schindler, Pamela S, *Business Research Methods*, Tata Mc Graw Hill , New Delhi 2004.

2. Poulin V Young, *Scientific social Surveys and Research*, Prentice Hall of India, New Delhi.

3. Kothari C.R, *Research Methodology*, Weshwa Prekashan New Delhi.

4. Krishnanswami O R, *Methodology of Research in Social Methodology: A step by step Guide for Beginners*, Sage Publishers, New Delhi.

5. Gibaldi, Joseph, *MLA Handbook for Writers of Research Papers*, Affiliated East West Press Pvt. Ltd., New Delhi 2000.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module. All questions carry equal (20) marks.

Module I
Question 1: 20 marks
Question 2: 20 marks
Module II
Question 3: 20 marks
Question 4: 20 marks
Module III
Question 5: 20 marks
Question 6: 20 marks
Module IV
Question 7: 20 marks
Question 8: 20 marks

MTS 10 302 (B): ADVANCED INTERNAL COMBUSTION ENGINES

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objective: *To provide knowledge on spark ignition engines, components of I.C engines, combustion modeling and stratified charge Engines.*

Module I (13 hours)

Spark Ignition Engines – Mixture requirements – Fuel – Injection systems – Monopoint-Multipoint injection, direct injection– Stages of combustion – Normal and abnormal combustion – Factors affecting knock – Combustion chambers.

Module II (13 hours)

Compression ignition engines, Stages of combustion in C.I. Engine – Direct and indirect injection systems – Combustion chambers – Fuel spray behaviour – spray structure, spray penetration and evaporation – air motion – Introduction to Turbo charging and supercharging.

Module III (13 hours)

Combustion modeling – Basic concepts of engine simulation, governing equations, simulation of various engine processes for SI and CI Engines – Thermodynamic and fluid mechanic based models.

Module IV (13 hours)

Alternative fuels, Alcohol, Hydrogen, Natural Gas Bio diesel, fuel cell – Other possible fuels an Liquefied Petroleum Gas – Properties, Suitability, Merits and Demerits as fuels, Engine Modifications. Dual fuel operation – Recent trends, Lean Burn Engines – Stratified charge Engines – Homogeneous charge compression ignition engines – Plasma Ignition – Zero Emission Vehicles, Engines for special applications – Mining, Defence, Off-highway – Tractor, Bulldozer etc. Submarines, Race car Engine systems, Flexible fuel systems – Surface ignition.

REFERENCES:

1. K.K.Ramalingam, *Internal Combustion Engine Fundamentals*, Scitech Publications, 2002.
2. John B Heywood, *Internal Combustion Engine Fundamentals*, McGraw Hill
3. M.L. Mathur and R.P.Sharma, *A course in internal Combustion Engines*, Dhanapat Rai Publications, New Delhi.
4. Duffy Smith, *Auto fuel Systems*, The Good Heart Willox Company, Inc.
5. Ganesan V., *Computer simulation of spark ignition process:* University process. Hyderabad1993.
6. Ganesan V., *Computer simulation of compression ignition engine*. Orient Long man 2000.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to student's right at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module. All questions carry equal (20) marks.

Module I
Question 1: 20 marks
Question 2: 20 marks
Module II
Question 3: 20 marks
Question 4: 20 marks
Module III
Question 5: 20 marks
Question 6: 20 marks
Module IV
Question 7: 20 marks
Question 8: 20 marks

MTS10 302 (C): FINITE ELEMENT METHODS

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objective*: To impart knowledge on the Application of Numerical Methods like FEM on various Heat Transfer and Fluid problems.*

Module I (12 hours)

Overview of numerical methods – Finite Element Methods, Finite Difference Methods, Finite Volume Methods in heat transfer and Fluid Flow. Discretized representation of physical systems - Thermal resistance, flow resistance networks, thermal capacitance - Governing equations and Boundary conditions for thermal and flow systems – FE formulation for 1-D heat conduction – Simple problems

Module II (12 hours)

Formulation Procedures: Principles of variational techniques– functionals – extremization of a functional - applications of variational approach to one dimensional heat conduction – Interpolation – shape function - element matrices and assembly - boundary conditions.
Weighted-residual methods – Galerkin's method – Application to 1-D heat conduction.

Module III (14 hours)

Isoparametric formulation: natural co-ordinates - 1-D and 2-D, linear and quadratic isoparametric elements – FE formulation for 2-D heat transfer using triangular elements – Radiation and convective boundary conditions – simple problems.
Numerical integration – Gauss quadrature for 1-D and 2D elements – Error in FE analyses – modeling considerations.

Module IV (14 hours)

FE formulation for transient heat transfer – element matrices – integration procedures for 1-D- Introduction to nonlinear problems- solution methods for 1-D.
FEM and FDM in flow problems, Incompressible laminar flow simulation– Stream function Vorticity methods, Velocity Pressure formulation, mixed order interpolation for incompressible flow, modifications for turbulent flow.
SOFTWARE CODES

Description of programs for heat conduction, Fluid flow, Assignment problems using these codes.

REFERNCES:

1. S.S. Rao Pergamon, *The Finite Element Method in Engineering.*, 2nd Edition, Pergamon Press,
2. Larry Segerlind, *Applied Finite Element Analysis,* 2nd Edition John Wiley & Sons, 1988.
3. J.N. Reddy, *Finite Elements Methods*, McGraw-Hill 1988.
4. Daryl L. Logan, *A First Course in the Finite Element Method*, Thomsen Education
5. Comini, Gianni, Nonino, Car, *Finite Element Analysis in Heat Transfer*: Basic
6. Taylor and Francis, *Formulation and Linear Problems*, Mc Graw Hill 1989
7. Ghoshdashthidar, P.S., *Computer Simulation of flow and heat transfer*. Tata McGraw- Hill Publishing Company Ltd., 1998.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

Semester end examination: 100 marks
Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module. All questions carry equal (20) marks.

Module I
Question 1: 20 marks
Question 2: 20 marks
Module II
Question 3: 20 marks
Question 4: 20 marks
Module III
Question 5: 20 marks
Question 6: 20 marks
Module IV
Question 7: 20 marks
Question 8: 20 marks

MTS10 303 (P): INDUSTRIAL TRAINING

Teaching scheme: 1 hour per week **Credits:** 1

The students have to undergo an industrial training of a minimum two weeks in an industry preferably dealing with Thermal Systems during the semester break after second semester and complete within 15 calendar days from the start of third semester. The students have to submit a report of the training undergone and present the contents of the report before the evaluation committee constituted by the department. An internal evaluation will be conducted for examining the quality and authenticity of contents of the report and award the marks at the end of the semester examination based on training quality, contents of the report and presentation.

Semester end examination: Marks 50

MTS10 304 (P): MASTER RESEARCH PROJECT PHASE - I

Teaching scheme: 22 hours per week **Credits:** 6

Objective: *To improve the professional competency and research aptitude by touching the areas which otherwise not covered by theory or laboratory classes. The project work aims to develop the work practice in students to apply theoretical and practical tools/techniques to solve real life problems related to industry and current research.*

The project work can be a design project/experimental project and or computer simulation project on any of the topics in Thermal Stream. The project work is allotted individually on different topics. As far as possible the students shall be encouraged to do their project work in the parent institute itself. If found essential, they may be permitted to continue their project outside the parent institute subject to the conditions in clause 10 of M.Tech regulations. Department will constitute an Evaluation Committee to review the project work.

The student is required to undertake the master's research project phase -I during the third semester and the same is continued in the 4^{th} semester (Phase-II). Phase-I consist of preliminary thesis work, two reviews of the work and the submission of preliminary report. First review would highlight the topic, objectives, methodology and expected results. Second review evaluates the progress of the work, preliminary report and scope of the work which is to be completed in the 4^{th} semester. The Evaluation committee consists of at least three faculty members of which internal guide and another expert in the specified area of the project shall be two essential members.

Internal Continuous assessment:

First Review:

Guide	50 marks
Evaluation Committee	50 marks

Second review:

Guide	100 marks
Evaluation Committee	100 marks
Total	**300 marks**

MTS10 401 (P): MASTERS RESEARCH PROJECT PHASE-II

Teaching scheme: 30 hours per week **Credits:** 12

Objective: *To improve the professional competency and research aptitude by touching the areas which otherwise not covered by theory or laboratory classes. The project work aims to develop the work practice in students to apply theoretical and practical tools/techniques to solve real life problems related to industry and current research*.

Masters Research project phase-II is a continuation of project phase-I started in the third semester. Before the end of the fourth semester, there will be two reviews one at middle of the IV semester and other towards the end. The progress of the project work done will be assessed in the first review, and in the second review, the complete assessment (quality and authenticity) of the Thesis, will be conducted by the Evaluation Committee. Second review would be a pre qualifying exercise for the students for getting approval by the Departmental Committee for the submission of the thesis. At least one technical paper related with Thesis is to be prepared for possible publication in journal or conferences. The Technical paper is to be submitted along with the Thesis. The final evaluation of the project will be external.

Internal Continues assessment:

First review:

Guide	50 marks
Evaluation committee	50 marks

Second review:

Guide	100 marks
Evaluation committee	100 marks

Semester end Examination:

Project Evaluation by External Examiner: 150 marks
Viva Voce by External and Internal Examiner: 150 marks (75 marks each)