# DEPARTMENT OF MECHANICAL ENGINEERING
## M. Tech (Thermal Engineering)
### SCHEME OF INSTRUCTION AND EXAMINATION

(with effect from 2015-16 academic year)

**I - SEMESTER**

<table>
<thead>
<tr>
<th>Code No.</th>
<th>Course title</th>
<th>Scheme of Instruction</th>
<th>Scheme of Examination</th>
<th>Total Credits</th>
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<tr>
<td>TE-1.1</td>
<td>Computation Methods in Engineering</td>
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<tr>
<td>TE-1.2</td>
<td>Computational Fluid Dynamics</td>
<td>4</td>
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<td>TE-1.3</td>
<td>Measurements in Thermal Systems</td>
<td>4</td>
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<tr>
<td>TE-1.4</td>
<td>Advanced Thermodynamics</td>
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<tr>
<td>TE-1.5</td>
<td>Elective Subject-1</td>
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<tr>
<td></td>
<td>a) Advanced Heat Transfer</td>
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<td></td>
<td>b) Boiling and Two-Phase flow heat Transfer</td>
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<td></td>
<td>c) Advanced Optimization Techniques</td>
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<td>Elective Subject-2</td>
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<tr>
<td></td>
<td>a) Advanced Fluid Mechanics</td>
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<td>b) Solar Energy and Technology</td>
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<td>c) Tribology</td>
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<tr>
<td>TE-1.7</td>
<td>Lab 1: Fuels and Lubricants Laboratory</td>
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<tr>
<td>TE-1.8</td>
<td>Lab 2: CFD Laboratory</td>
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**Note:**
The viva-voce for the labs / seminars shall be held with the course instructor/ faculty member and an external examiner nominated by the university from any academic institution / industry / R & D organization.
### II – SEMESTER

<table>
<thead>
<tr>
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<tr>
<td>TE-2.1</td>
<td>Thermal, Nuclear, Hydel, and OTEC Power Plants</td>
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<td>TE-2.2</td>
<td>Energy Conservation in Thermal Systems</td>
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<td>TE-2.3</td>
<td>Alternative Fuels and Advances in IC Engines</td>
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<td>TE-2.4</td>
<td>Design of Thermal Equipment</td>
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<td>a) IC Engine Combustion and Air-Pollution</td>
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<td>b) Steam turbines, Gas turbines and Jet Propulsion</td>
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<td>c) Mechatronics</td>
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<td>a) Energy Management</td>
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<td>b) Refrigeration and Air-Conditioning</td>
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<td>c) Thermal Management of Electronic Equipment</td>
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<td>TE-2.7</td>
<td>Lab-1: IC Engines and gas Turbine Laboratory</td>
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<td><strong>30</strong></td>
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**Note:** The viva-voce for the labs / seminars shall be held with the course instructor/ faculty member and an external examiner nominated by the university from any academic institution / industry / R & D organization.
### III – SEMESTER

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<td>Dissertation (Preliminary)</td>
<td>Viva-voce</td>
<td>100</td>
<td>12</td>
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</table>

**Note:** The Dissertation shall be evaluated through Viva–Voce examination by a committee with HOD, Chairman, Board of studies and Research Guide as members. The marks shall be awarded in the ratio of 30, 30, and 40 percent by the members respectively.

### IV – SEMESTER

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<thead>
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</table>

**Note:** The Dissertation shall be evaluated through Defense and Viva–Voce examination by a committee with an External Examiner nominated by University, HOD, Chairman, Board of studies and Research Guide as members. The marks shall be awarded in the ratio of 20, 20, 20, and 40 percent by the members respectively.
FIRST SEMESTER

TE-1.1: COMPUTATIONAL METHODS IN ENGINEERING

Periods/Week: 4 Th.  
Examination (Theory): 3 hrs.  
Ses.30 Exam: 70  
Credits: 4


Numerical solution of linear equations: Gauss Jacobi; Gauss Seidel iterative methods-method of least square for curve fitting. Eigen value problems

Interpolation Methods: Errors in polynomial interpolation-Finite differences: Forward, Backward, Central differences-Interpolation Formulae: Newton Forward formula, Newton Backward formula, Gauss, Stirling’s, Bessel’s, Everett’s Formulae-Interpolation with unequal spaced points: Lagrange’s interpolation, Newton’s divided difference-Inverse interpolation.


References:
TE-1.2: COMPUTATIONAL FLUID DYNAMICS

Periods/week: 4 Th. Ses.: 30 Exam: 70
Examination (Theory): 3hrs. Credits: 4

Introduction: Finite difference method, finite volume method, finite element method, Philosophy of Computational Fluid Dynamics: Computational fluid dynamics: Why? – Computational fluid dynamics as a research tool – Computational fluid dynamics as a design tool – The impact of Computational fluid dynamics—some other examples; Automobile and engine applications; Industrial manufacturing applications; Civil engineering applications; Environmental engineering applications; Naval architecture applications (submarine example) - Computational fluid dynamics: What is it?. Governing equations and boundary conditions. Derivation of finite difference equations.


Hyperbolic equations: explicit schemes and Von Neumann stability analysis, implicit schemes, multi step methods, nonlinear problems, second order one-dimensional wave equations.
Burgers equations: Explicit and implicit schemes, Runge-Kutta method.
Formulations of incompressible viscous flows: Formulations of incompressible viscous flows by finite difference methods, pressure correction methods, vortex methods.
Treatment of compressible flows: potential equation, Euler equations, Navier-stokes system of equations, flowfield-dependent variation methods, boundary conditions, example problems.
Finite volume method: Finite volume method via finite difference method, formulations for two and three-dimensional problems.
Standard variational methods: Linear fluid flow problems, steady state problems, Transient problems.

References:
TE-1.3: MEASUREMENTS IN THERMAL SYSTEMS

Periods/week: 4 Th.                                          Ses.: 30          Exam: 70
Examination (Theory): 3hrs.                                          Credits: 4

**Basic electrical measurements and sensing devices:** Transducers, The variable - Resistance transducers, The differential transformer (LVDT), Capacitive transducers, Piezoelectric transducers, Photoelectric effects, Photoconductive transducers, Photovoltaic cells, Ionization transducers, Magnetometer search coil: Hall-effect transducers.

**Pressure measurements:** Dynamic response considerations, Mechanical pressure - Measurement devices, Dead-weight tester, Bourdon-tube pressure gauge, Diaphragm and bellows gauges, The Bridgman gauge, Low-pressure measurement. The Mcleod gauge, Pirani thermal-conductivity gauge, The Knudsen gauge, The ionization gauge, The alphatron.


**The measurement of temperature:** Temperature scales. The ideal-gas thermometer, Temperature measurement by mechanical effect. Temperature measurement by electrical effects, Temperature measurement by radiation, Effect of heat transfer or temperature measurement, Transient response of thermal systems, Thermocouple compensation, Temperature measurements in high-speed flow.


**Thermal radiation measurements:** Detection of thermal radiation, Measurement of emissivity, Reflectivity and transmissivity measurements, Solar radiation measurements.

**References:**
1. Experimental Methods for Engineers by Holman, J.P.
Introduction: Macroscopic approach, First, Second, and 3rd law of thermodynamics, and its applications, thermodynamic potentials, generalized relations for Cp and Cv.

Thermodynamic relations and Entropy: Cyclic and reciprocity relations, general relations: Iso-thermal compressibility and coefficient of volume expansion. Concepts of entropy: entropy flow, entropy generation during heat transfer and thermodynamic processes, Gibbs and Helmholtz relations, Maxwell relations, T.dS equations, Heat capacity equation, entropy change, isentropic efficiency, T-s diagrams, effect of efficiency on compressor input, and nozzle exit velocity, entropy generation associated with heat transfer, Joule-Thomson coefficient, Clapeyron equation, Basic principles of liquefaction: Liquefaction of gases, Storage and uses of cryogenic fluids, Exergy: Reversible work/Maximum power output, Irreversibility, availability function, second law analysis and efficiency, change of exergy, and exergy destruction

Chemical Reactions: Fuels and combustion, elemental analysis of fuels, thermo-chemistry, combustion equations, reverse combustion analysis, evaluation of enthalpy of combustion, analysis of steady flow combustion, analysis of combustion in bomb, adiabatic flame temperature, reversible work associated with combustion and second law analysis of isothermal and adiabatic combustion


Thermodynamics of high speed gas flow: Stagnation properties, compression of high speed air and sound, Mach number and its applications, isentropic flow, air/gas flow through C-D duct/nozzle, Tc and Pc in gas flow, back pressure, shock wave in C-D nozzle, flow through non-isentropic nozzles.

Reference Books:

• Thermodynamics—K Wark and D.E.Richards, 6/e, McGraw-Hill, New York, 1999
• Engineering Thermodynamics (5/e) - P K Nag
• Chemical Engineering Thermodynamics—Y V C Rao
TE-1.5: ADVANCED HEAT TRANSFER
(Elective-I)

Periods/week: 4 Th.                          Ses. : 30  Exam: 70
Examination (Theory): 3hrs.                  Credits: 4

**Brief Introduction to different modes of heat transfer:** Conduction- General heat conduction equation- Boundary conditions- One dimensional heat transfer with internal heat generation- Fins- Transient heat conduction- Lumped system analysis- Heisler charts- Semi infinite solid- Use of shape factors in conduction.

**Finite difference method:** One dimensional steady state heat conduction- Boundary conditions– Two dimensional steady state heat conduction- Cylindrical and spherical geometry- unsteady state heat conduction- Implicit and explicit methods.

**Convection:** Equation of momentum and energy- integral solution of momentum and energy equations- Exact solutions- Boundary layer- Forced convection- External and internal flows- calculation of heat transfer coefficient for different geometries.

**Free convection for different geometries:** Combined free and forced convection. Boiling and condensation: Boiling curve- Correlation- Nusselt’s theory of film condensation.

**Radiation mechanism:**- Radiant heat exchange in grey- Non grey bodies- with transmitting- reflecting and absorbing media- Specular surfaces- Gas radiation- radiation from flames.

**References:**
1. Incropera F.P. and DeWitt D.P., Fundamentals of heat and mass transfer, John Wiley and sons
Definitions: Types of flow; volumetric concentration; void fraction; volumetric flux; relative velocity; drift velocity; flow regimes; flow maps; analytical models.

Homogeneous flow: One-dimensional steady homogeneous equilibrium flow; homogeneous friction factor; turbulent flow friction factor.

Separated flow: Slip; Detailed discussion on bubbly, slug and annular flow; Lockhart-Martinelli method for pressure drop calculation; pressure drop for flow with boiling; flow with phase change.

Drift flow model: General theory; gravity flows with no wall shear; correlation to simple theory; Armond or Bankoff flow parameters.

Boiling: Regimes of boiling; nucleation; growth of bubbles; bubble motion at a heating surface; heat transfer rates in pool boiling; Rohsenow correlation for nucleate boiling. Zuber's theory for critical heat flux. Bromley theory for film boiling; forced convection boiling; Chen's correlation for flow boiling; maximum heat flux or burn out.

Condensation: Nusselt's theory; boundary layer treatment of laminar film condensation; experimental results for vertical and horizontal tubes; condensation inside a horizontal tube.

References:
2. Boiling heat transfer and two phase flow by L.S. Tong, John Wiley.
3. Liquid- vapor phase change phenomenon by V.P.Carey, Taylor and Francis.
4. Heat transfer by J.P. Holman.
5. One-dimensional two-phase flow by Wallis, McGraw-Hill.
8. Transport processes in boiling and two-phase flow systems by Hsu and Graham, McGraw-Hill.
TE-1.5: ADVANCED OPTIMIZATION TECHNIQUES
(ELECTIVE-I)

Periods/week: 4 Th.                             Ses. : 30   Exam: 70
Examination (Theory): 3hrs.                                                                              Credits: 4


**Dynamic programming (D.P):** Multistage decision processes. Concepts of sub optimization and Principal of optimality, computational procedure in dynamic programming calculus method and tabular methods. Linear programming as a case of D.P. and continuous D.P


**Stochastic Programming (S.P.):** Basic Concepts of Probability Theory, Stochastic Linear programming.

**Non-traditional optimization techniques:** Multi-objective optimization – Lexicographic method, Goal programming method, Genetic algorithms, Simulated annealing, Neural Networks based Optimization.

**References:**
1. Operations Research- Principles and Practice by Ravindran, Phillips and Solberg, John Wiely
5. Genetic Algorithms - In Search, Optimization and Machine Learning by David E. Goldberg, Addison-Wesley Longman (Singapore) Pvt. Ltd.
Ideal and non-ideal flows, General equations of fluid motion, Navier-Stokes equations and their exact solutions.

Boundary layer theory, solutions to flow over external surfaces, flow through internal surfaces, integral methods, steady laminar and turbulent incompressible flows.

Introduction to compressible viscous flows, governing equations.

Fanno and Rayleigh lines.

Normal and oblique shocks.

References:

2. Foundations of fluid mechanics by Yuan, Prentice Hall.
3. Turbulence, Bradshaw by Springer-Verlag.
TE-1.6: SOLAR ENERGY TECHNOLOGY
(ELECTIVE-II)

Periods/week: 4 Th.
Examination (Theory): 3hrs.

Ses. : 30 Exam: 70
Credits: 4


Power generation: solar central receiver system – heliostats and receiver – heat transport system – solar distributed receiver system – power cycles – working fluids and prime movers


Direct energy conversion: Solid state principles- semiconductors-solar cells-performance-modular construction-applications

Other solar devices: stills – air heaters- driers


References:
1. G.D.Rai” Solar Energy Utilization”Khanna Publishers
4. Kaushik S.C.Tiwari G.N. and Nayak I.K ”Thermal control in passive solar buildings”
Introduction: Defining Tribology, Tribology in Design - Mechanical design of oil seals and gasket - Tribological design of oil seals and gasket, Tribology in Industry (Maintenance), Defining Lubrication, Basic Modes of Lubrication, Properties of Lubricants, Lubricant Additives, Defining Bearing, Terminology - Sliding contact bearings - Rolling contact bearings, Comparison between Sliding and Rolling Contact Bearings


Hydrostatic Thrust Bearing: Introduction - Flat plate thrust bearing - Tilting pad thrust bearing, Pressure Equation - Flat plate thrust bearing - Tilting pad thrust bearing, Load - Flat plate thrust bearing - Tilting pad thrust bearing, Center of Pressure - Flat plate thrust bearing - Tilting pad thrust bearing, Friction - Flat plate thrust bearing - Tilting pad thrust bearing

Hydrostatic and Squeeze Film Lubrication: Hydrostatic Lubrication - Basic concept - Advantages and limitations - Viscous flow through rectangular slot - Load carrying capacity and flow requirement - Energy losses - Optimum design. Squeeze Film Lubrication - Basic concept - Squeeze action between circular and rectangular plates - Squeeze action under variable and alternating loads, Application to journal bearings, Piston Pin Lubrications


Gas (Air) Lubricated Bearings: Introduction, Merits, Demerits and Applications, Tilting pad bearings, Magnetic recording discs with flying head, Hydrostatic bearings with air lubrication, Hydrodynamic bearings with air lubrication, Thrust bearings with air lubrication
Tribological Aspects of Rolling Motion: The mechanics of tyre-road interactions, Road grip and rolling resistance, Tribological aspects of wheel on rail contact


References:
- Tribology in Indertrion- By Sushil Kumar Srivastava
- Introduction to Tribology of Bearings- By B.C. Majumdar ; A.H.Wheeler
- Principles of Tribology – By J. Halling, Macmillan
- Mechanics and Chemistry in Lubrication- By Dorinson and Ludema, Elsevier
- Friction and wear of Materials- By E. Robinowicz, Johan Wiley
- Principles of Lubrication-By A. Cameron, Longmans
TE-1.7: FUELS AND LUBRICANTS LABORATORY

- Determination of calorific values of fossil and alternate fuels: liquid, gaseous, and solid fuels
- Calibration of pressure (vacuum and low and high pressure gauges) gauges and temperature gauges (below and above zero degrees Celsius).
- Determination of kinematics’ viscosities of fossil fuels
- Determination of kinematics’ viscosities of alternative liquid fuels (Biofuels)
- Determination of viscosities multi-grade lubricants

TE-1.8: CFD LABORATORY

Periods/week: 3 Pr.                     Ses. : 50          Exam: Nil
Examination (Practicals): --            Credits: 2

MATLAB programming for problem solving of Fluid Mechanics, Thermal Engineering and Heat Transfer Problems

C programming for problem solving of Fluid Mechanics, Thermal Engineering and Heat Transfer Problems

Solving Thermal Engineering problems using available packages such as T K Solver: ANSYS, CFX, STARCD, MATLAB, FLUENT etc…
SECOND SEMESTER

TE-2.1: THERMAL, NUCLEAR, HYDEL AND OTEC POWER PLANTS

Periods/week: 4 Th.  
Ses.: 30  
Exam: 70  
Credits: 4

Thermal Power Plants: Constructional features and working principle of thermal power plants: steam based and gas based power plants


References:
1. Black and Veatch. “ Power Plant Engineering” CBS publishers and distributors
2. GD Rai, Non conventional energy sources, Khana publishers
3. Power Plant Engineering – Arora and Domkundwar, Dhanpat Rai
M.A.
TE-2.2: ENERGY CONSERVATION IN THERMAL SYSTEMS


Thermal Energy Transmission /Protection Systems: Steam traps – refractories – optimum insulation thickness – insulation – piping design

Financial Management: Investment - need, appraisal and criteria, financial analysis techniques - break even analysis- simple pay back period, return on investment, net present value, internal rate of return, cash flows, DSCR, financing options, ESCO concept.

References:
3. Trivedi, PR, Jolka KR, Energy Management, Commonwealth Publication, New Delhi,

Alternate Liquid and Gaseous Fuels: Alcohol based fuels: Methanol and Ethanol, Di-Ethyl-Ether (DEE) and Di-Methyl-Ether (DME); Synthetic diesel: Fischer-Tropsch diesel (FTD), Compressed natural gas (CNG), Liquefied petroleum gas (LPG), Liquefied natural gas (LNG), Hydrogen (H$_2$); safety precautions, handling/transportation issues, and environmental impact of fuels, Fuel Cells: constructional features and working principle, Merits and de-merits of alternate fuels.

Second and Third Generation Bio-Fuels: Vegetable oils (forest based): use and limitations, Physico-chemical properties and emission characteristics, necessity of esterification and transesterification; Biodiesel (Ethyl and Methyl Esters) produced from vegetable oil feed stocks: Jatropha curcas, Pongamia pinnata/Karanja, Mahua, Palm kernel, Cotton seed, and Micro-Algae; animal feed stocks: Tallow; Processing and Storage methods, National and International Bio-fuel standards: Indian, ASTM (D-6751), European (EN-14214), Japan, and Germany standards.

Engine Electronics: Types and principles of engine sensors: measurement of thermo-physical properties: Air flow, pressure, temperature, oxygen, rpm, torque/load, detonation, position/timing of dead centers and fuel injection systems, electronic ignition, Electronic control module (ECM), Engine management systems, Fuel management systems, digital control techniques, and open & closed loop systems

Modern Engine Technologies: Constructional features and working principle of: DI and IDI engines; Technologies for BS III and IV norms: tuned manifolds, cam-less valve gearing, variable valve actuation/timing(VVT), multi-valve engines, gasoline direct injection (GDI) engines: TBI and MPFI engines; fuel injection strategies, high pressure diesel injection: Common rail direct injection (CRDI-up to 2000 bar) engines, variable compression ratio (VCR) engines, Variable geometry turbo charging (VGT), Variable geometry intercoolers, glow plug, EGR (exhaust gas recirculation) system, HCCI (homogeneous charge compression ignition) engines, Dual-Fuel Technology: CNG-Gasoline, Hydrogen-Diesel, and Alcohols-Diesel, advantages and disadvantages; and race car engines.
Reference Books:

- Present and Future Automotive Fuels, Osamu Hirao and Richard K Pefley, John Wiley and sons, 1988
- Automobile Electrical and Electronic Systems, by Tom Denton, SAE International, USA, 2000
- Internal Combustion Engines and Air Pollution, by Edward F. Obert
TE-2.4: DESIGN OF THERMAL EQUIPMENT

Periods/week: 4 Th.                      Ses. : 30      Exam: 70
Examination (Theory): 3hrs.                        Credits: 4

Classification of Thermal Equipment – Applications; Heat exchangers – a classification; basic
derign methods for heat exchangers; double pipe heat exchangers, parallel and counter flow.

Design of shell and tube heat exchangers; TEMA codes; flow arrangements for increased heat
recovery; Condensation of single vapors, mixed vapors;

Design considerations for different plate type heat exchangers;

Regenerators, Steam generators, Condensers, Radiators for space power plant, cooling towers.

Power plant Heat Exchangers, Furnace Calculations

References:
2. Heat Exchangers Selection, Rating and Thermal Design- Sadik Kakac and Hongtan Liu,
   CRC Press.
5. Heat exchanger design- Press and N. Ozisik.
Fuels Chemistry and Combustion Principles: Basic principles of combustion: heat of combustion, concepts of combustion, chemical reactions, stoichiometry, and CHNO analysis, air requirements, Theories of combustion, theoretical flame temperature/adiabatic flame temperature, pre-flame reactions, laminar and turbulent flame propagation in engines, chemical equilibrium and dissociation

Combustion in IC Engines: Combustion in SI engines: Ignition, flame velocity, Normal and abnormal combustion, knocking, pre-ignition, effect of engine variables on knocking, features and design consideration of combustion chambers, concept of lean burn engines, Combustion in CI engines: Air motion: Swirl and squish, spray formation and vaporization, Stages of combustion, physical and chemical delay, diesel knock, effect of engine variables on diesel knock, combustion chambers: design features, Combustion characteristics of Biodiesel and Biodiesel blends, Low NOx diesel combustion: homogeneous charge compression ignition engine (HCCI- combustion), pHCCI, and EGR techniques


Engine Emissions and Air-Pollution: Emissions and its Formation: Gaseous emissions: CO, CO$_2$, HC, NOx (NO & NO$_2$), SOx (SO$_2$ & SO$_3$); particulate matter (PM), Sources of emission formation; Emissions formation mechanisms of PM and NOx; volatile organic compounds (VOCs), poly aromatic hydrocarbons (PAH), soluble organic fraction (SOF); Mechanism of air pollution: Ozone depletion, Greenhouse effect, Photochemical smog, acid rain, Effect of air-pollution on health and environment, Emission norms (passenger and commercial vehicles): National and International emission standards: BS-III and BS-IV & Euro III, IV, and V

Emission Control Technologies and Emission Measurements: PM reduction technologies: Diesel oxidation catalysts (DOCs), Diesel particulate filters (DPFs), closed crankcase ventilation (CCV); NOx reduction technologies: Exhaust gas recirculation (EGR), Selective catalytic reduction (SCR), Lean NOx catalysts (LNCs), Lean NOx traps (LNTs), NOx adsorber catalysts, Exhaust gas recirculation (EGR), Diesel exhaust after treatment: diesel oxidation catalyst (DOC),
diesel particulate filter (DPF), Soot suppression by fuel additives, relationship: soot, combustion chamber and swirl ratio, catalytic convertors: constructional features and types: 2-way and 3-way catalytic convertors. Measurement of gaseous emissions using thermal, chemical, magnetic and optical gas analyzers: infrared gas analyzer, chemiluminescent analyzer, gas chromatography, smoke (soot) measurement, application of microprocessor in emission control.

Trends of emission reduction

Reference Books:

- Thermodynamic Analysis of Combustion Engines, by Ashley S Campbell, John Wiley and Sons, 1980
- Internal Combustion Engines and Air Pollution, by Edward F Obert, Intext Education Publishers, 1980
- Automotive Emission Control, Couse William, Gregg division, McGraw-Hill,
**TE- 2.5: MECHATRONICS**

*(ELECTIVE-3)*

Periods/week: 4 Th.                               Ses. : 30          Exam: 70
Examination (Theory): 3hrs.                                                                                 Credits: 4

**Electrical Systems:** Mathematical modeling of Electro Mechanical Systems, RLC Circuits, active and passive electrical circuits, PMDC Motor, Stepper motor, three phase squirrel cage induction motor, three phase permanent magnet synchronous motor, servo motor.

**Mechanical Systems:** Introduction to various systems of units, mathematical modeling of mechanical systems, Newton’s laws, moment of inertia, forced response and natural response, rotational systems, spring mass system, free vibration, spring mass damper system, mechanical systems with dry friction, work energy and power, passive elements and active elements an energy method for deriving equations of motion, energy and power transformers.


**Design of Mechanical Elements:** The phases of design, Design considerations, codes and standards, optimum design process, design variables, cost functions, design constraints, optimum design. Springs, rolling contact bearing, journal bearing, Spur and helical gear, bevel and worm gears, shafts, axes and spindles, Flexible Mechanical Elements, Belts, timing belts, chain and sprocket, flexible shafts, brakes, clutches, cams, four bar mechanism.

**Design of Hydraulic System:** Hydraulic circuit design, Actuator design, selection of pumps, selection of valves, design of control circuits.

**References:**
TE 2.6 ENERGY MANAGEMENT  
(ELECTIVE-4)  

Periods/week: 4 Th.                           Ses. : 30   Exam: 70  
Examination (Theory): 3hrs.                 Credits: 4  


Synthesis of alternative options and technical analysis of options, Process integration.


Text Books:
2. Management by H.Koontz and Cyrill O Donnell  
3. Financial Management by S.C. Kuchhal  
6. Energy Management by Trivedi, PR, Jolka KR, Commonwealth publication, New Delhi  
REFERENCES:

3. Energy Economics/A.V.Desai/Wieley Eastern

TE-2.6: REFRIGERATION AND AIR CONDITIONING
(ELECTIVE-4)

Periods/week: 4 Th. Ses. : 30 Exam: 70
Examination (Theory): 3hrs. Credits: 4

Refrigeration Cycles and Analysis: Development of Vapor Compression Refrigeration Cycle from Reverse Carnot Cycle- conditions for high COP-deviations from ideal vapor compression cycle, Multi-pressure Systems, Cascade Systems-Analysis.

Main System Components: Compressor- Types, performance, Characteristics of Reciprocating Compressors, Capacity Control, Types of Evaporators & Condensers and their functional aspects, Expansion Devices and their Behavior with fluctuating load.


Summer and Winter Air Conditioning: Air conditioning processes-RSHF, summer Air conditioning, Winter Air conditioning Bypass Factor. Applications with specified ventilation air quantity- Use of ERSHF, Application with low latent heat loads and high latent heat loads.

Load Estimation and Air Conditioning Controls: Solar Radiation-Heat Gain through Glasses, Heat Transfer through Walls and Roofs-Total cooling load estimation. Controls of temperature, Humidity, and Airflow

References:
8. Refrigeration and Air Conditioning (3/e) - Langley Billy C., Engie wood Cliffs (N.J) PHI.

**TE- 2.6: THERMAL MANAGEMENT OF ELECTRONIC EQUIPMENT**
*(ELECTIVE-4)*

Periods/week: 4 Th. Ses.: 30 Exam: 70
Examination (Theory): 3hrs. Credits: 4

Modes of heat transfer, Heat transfer coefficient.

Power transistors, Power diodes, Central processing units (CPUs)


Heat transfer compounds, Thermally conductive pastes, Epoxy resins, Liquid cooling of electronic devices, Liquid coolants and alternative liquid coolants for high density electronics,

Heat pipes, Technical characteristics of heat pipes, Micro channel, and two-phase cooling, Cooling methods with phase change: Evaporation and Condensation.

Thermoelectric cooling: Thermoelectric cooling principles (TEC), Applications in electronics systems, Peltier effect of cooling and semi conductors, Cooling of automotive electronics, Specification of power dissipation, Trends in thermal management.

**Reference Books:**


**TE-2.7: I.C. ENGINES AND GAS TURBINE LABORATORY**

Periods/week: 3 Pr.  
Ses.: 50  Exam: 50  
Examination (Practical’s):  ---  
Credits: 3

• Determination of Performance Characteristics of Single cylinder (stationery) Petrol Engines  
• Determination of Performance Characteristics of Single cylinder (stationery) Diesel Engines  
• Determination of Sankey diagram for variable speed/load engines  
• Determination of Morse Test on MPFI Engine  
• Determination of Performance Characteristics (Power/Torque) of Automotive Engines

**TE-2.8: I.C. ENGINE COMBUSTION AND EMISSIONS LABORATORY**

Periods/week: 3 Pr.  
Ses.: 50  Exam: 50  
Examination (Practical’s):  ---  
Credits: 3

**List of Experiments:**

• Measurement of injection pressure and cylinder pressure of stationery and automotive Engines.  
• Determination of net and cumulative (gross) heat release rates of an IC engines (Gasoline, Diesel and VCR Engines) from cylinder pressure.  
• Determination of mass fraction (fuel) burned during combustion in IC engines (Gasoline, Diesel and VCR Engines)
• Measurement of smoke (soot) emissions of Gasoline, Diesel and Bio-Fuel Engines
• Measurement of Gaseous emissions (HC, CO, CO$_2$, NO$_x$, SO$_x$, and O$_2$) of Gasoline, Diesel and Bio-Fuel Engines

THIRD SEMESTER & FOURTH SEMESTER

Student has to complete ONE YEAR PROJECT (TE-301 E), in the areas of thermal engineering. The research areas are mainly the current trends in mechanical engineering in particular thermal engineering related subjects (core or electives).

The standard of the thesis must be Masters Degree Level and he/she should publish/communicate their research work to any referred journal/conference of national or international level.