Form: **MP 06 (i)**
(Clause 9.5.1)

Motilal Nehru National Institute of Technology Allahabad

1. Course Structure of M. Tech. Mechanical Engineering(Thermal Engineering)

I Semester:

S. No.	Subject Name	Code	L	T	P	Cr
1.	Heat and Mass Transfer	ME21121	4	0	0	4
2.	Energy Conversion Techniques	ME21122	4	0	0	4
3.	Elective I		4	0	0	4
4.	Elective II		4	0	0	4
5.	Elective III		4	0	0	4

Total Credits = 20

II Semester:

S. No.	Subject Name	Code	L	T	P	Cr
1.	Design of Thermal Systems	ME22123	4	0	0	4
2.	Thermal Engineering Laboratory	ME22221	0	0	8	4
3.	Elective IV		4	0	0	4
4.	Elective V		4	0	0	4
5.	Elective VI		4	0	0	4

Total Credits = 20

III Semester:

S. No.	Subject Name	Code	Credits
1.	State of the art Seminar / Special Study / Term Project	ME23671	4
2.	Thesis	ME23621	16

IV Semester:

S. No.	Subject Name	Code	Credits
1.	Thesis	ME24621	20

Note: The distribution of thesis evaluation marks will be as follows.

1. Supervisor (s) evaluation component: 60%
2. Oral Board evaluation component: 40%

List of Electives in Thermal Engineering

M. Tech Mechanical Engineering (Thermal Engineering)

Elective-I		
Sl. No.	**Subject Code**	**Subject Name**
1	ME21361	Computational Methods in Engineering
2	ME21362	Experimental Methods in Engineering
3	ME21363	Optimization Methods in Engineering

Elective-II		
Sl. No.	**Subject Code**	**Subject Name**
1	ME21364	Alternative Fuels Technology
2	ME21365	Engine Tribology
3	ME21366	Design of Cryogenic System

Elective-III		
Sl. No.	**Subject Code**	**Subject Name**
1	ME21367	Gas Turbine and Jet Propulsion
2	ME21368	Design of Thermal Turbomachines
3	ME21369	Marine Engines and Propulsion

Elective-IV		
Sl. No.	**Subject Code**	**Subject Name**
1	ME22370	Design of Air Conditioning System
2	ME22371	Control of Automotive System
3	ME22372	Internal Combustion Engines and Pollution

Elective-V		
Sl. No.	**Subject Code**	**Subject Name**
1	ME22373	Computational Fluid Dynamics
2	ME22374	Exergy Analysis of Thermal Systems
3	ME22375	Design and Analysis of Solar Energy Systems

Elective-VI		
Sl. No.	**Subject Code**	**Subject Name**
1	ME22376	Energy System and Management
2	ME22377	Fuels and Combustion Engineering
3	ME22378	Thermo-fluid Dynamics

Mechanical Engineering Department

Course Code: **ME21121**
Course Name: **Heat and Mass Transfer**

1. Conduction concepts; One dimensional steady state conduction with and without heat sources; Fins of constant and variable cross sectional area;

2. Transient heat conduction; Multidimensional steady state heat conduction problems with and without heat sources; Heat conduction in anisotropic media.

3. Convection, Reynolds transport theorem and transport equations; One dimensional problems-Couette flow, Poisuille flow etc.; Forced convection in thermally developed and developing flows; Derivation of boundary layer equations by order of magnitude analysis; Solution of boundary layer equations by similarity variable and integral methods;
4. Introduction to natural convection; Natural convection in boundary layers; Integral method, Scaling analysis. Boiling and condensation.
5. Radiation, surface properties, view factors; Radiation exchange in black and grey enclosure; Electrical analogy, Interaction of surface radiation with other mode of heat transfer.

6. Mass Transfer, Fick's law of diffusion; Species conservation equation; Solution of one dimensional mass transfer problem.

References:

1. Fundamentals of Heat and Mass Transfer by Frank P. Incropera.
2. Heat & Mass Transfer: A Practical Approach by Yunus A. Çengel.
3. Heat Transfer: A Basic Approach by M.N. Ozisik.

Mechanical Engineering Department

Course Code: **ME21122**
Course Name: **Energy Conversion Techniques**

Combined cycle power plants, MHD power generation, Nuclear power plants: thermal fission, breeder and fusion reactors, environmental aspects of power generation. Ocean, wave and tidal energy: Ocean thermal energy conversion – closed and open cycles and their limitations, Wave energy and its conversion. Geothermal energy: hot aquifers and hot dry rock systems. Advanced solar thermal systems for power generation; emerging solar photovoltaic techniques.

References:

1. Power Plant Technology by Mohamed Mohamed El Wakil, McGraw-Hill, 1984
2. Renewable energy sources and conversion technology by Bansal, Kleemann and Meliss, Tata McGraw-Hill, 1990
3. Solar Energy – principles of thermal collection and storage by Sukhatme and Nayak, Tata McGraw-Hill, 2008
4. Principles of Solar Engineering by Goswami, Kreith and Kreider, Taylor & Francis, 2000.

Mechanical Engineering Department

Course Code: **ME22123**
Course Name: **Design of Thermal Systems**

1. Basic concepts and overview of thermal system design. Workable and optimum systems. Illustration through examples and case-studies.

2. Cogeneration and tri-generation systems: benefits, constraints, and applications; Combined cooling and power systems e.g. Goswami cycle.

3. Heat Pumps and their applications, Mechanical Vapour Recompression systems,

4. Cascaded V-C and V-A refrigeration systems, Energy recovery in refrigeration and air-conditioning systems. Circulating water systems: once through and closed loop systems.

5. Seminar presentations on modern developments in thermal systems along with their design, operation and economic aspects.

References:

1. Design of Thermal Systems by W F Stoecker, McGraw-Hill book company, 3rd ed, 1989.
2. Principles of Solar Engineering by Goswami, Kreith and Kreider; Taylor and Francis, 2000
3. Essentials of Thermal System Design and Optimization by C. Balaji, Ane Books Pvt. Ltd, 2011.

Mechanical Engineering Department

Course Code: **ME22221**
Course Name: **Thermal Engineering Laboratory**

1. Estimation of thermal conductivity of metal bar.
2. Study of the heat transfer in natural convection apparatus.
3. Study of the Stefen-Boltzman apparatus and estimation of Stefen-Boltzman’s constant.
4. Measurement of overall current-voltage characteristic of two crystalline & solar cell connected on series & parallel.
5. Observation and measurement of beam radiation, diffused radiation, global radiation, relative humidity of air, velocity of air and light intensity.
6. Measurement of daylight and artificial light intensity at various points in a room and plot the graph.
7. Estimation of the calorific value of fuel in bomb calorimeter.
8. Study of steam power plant.
9. Estimation of the burning velocity of gaseous fuel.
10. Study of vapor compression refrigeration cycle and vapor abroption refrigeration cycle.
11. Performance analysis of IC engines.
12. Study of Biodiesel, its preparation and determining its calorific value.
13. Thermal design study.
14. Industry or field visit.

Mechanical Engineering Department

Course Code: **ME21361**
Course Name: **Computational Methods in Engineering**

Introduction to Discretization Methods: Finite difference method (FDM, Finite element method (FEM) and Boundary Element Method (BEM)

Finite Differential Method (FDM): Introduction, history, applications, merits and demerits of FDM; Discretization Methods: Method for solving discretization equations, Consistency, stability and convergence; Representation of a Derivative; Backward Difference; Central difference; Forward, backward and central difference stencil; Stencil in y direction; 2nd Order and Mixed Derivative; Boundary Consideration; Polynomial Approach; Order of Approximation; Application of FDM to thermal engineering problems: 1D Steady State Conduction; Treatment of Boundary Condition; Algebraic Equations and Matrix Form; Unsteady Heat Conduction with FDM; Extensive Application to transient heat transfer by FDM. Use of FDM for finding solution of 2D and 3D heat transfer problems: Steady State Heat Conduction; Flux Boundary Condition, Convective Boundary Condition and Insulated Boundary;

Finite Element Method (FEM): Introduction, history, applications, merits and demerits of FEM; Variational and Weighted Residual Approaches of FEM; Finite Elements and Interpolation Functions (1D, 2D and 3D); Finite Element Formulation (Variational and Galerkin's) of 1D, 2D and 3D Heat transfer Problems; FE formulation of 1D heat transfer with mass Transport using Galerkin's method

Boundary Element Method (BEM): Introduction, history, applications, merits and demerits of BEM; Approach of BEM; Numerical Implementation: Determination of C_i; Tackling kernel singularity; 3D BE formulation for transient heat transfer problems; Examples: Temperature distribution in cutting tool, thermal design of blast furnace bottom and laser heating problems.

References

1. Numerical Heat Transfer and Fluid Flow by S. V. Patankar, Hemisphere Publishing Corporation
2. Computational Fluid Mechanics and Heat Transfer by D. A. Anderson, J. C. Tannehill, and R. H. Pletcher, Hemisphere Publishing Corporation
3. The Finite Element Method in Engineering by S.S. Rao, Butterworth Heinemann, Boston
4. Finite and Boundary Element Methods in Engineering by O.P. Gupta, Oxford & IBH Publishing

Mechanical Engineering Department

Course Code: **ME21362**
Course Name: **Experimental Methods in Engineering**

Generalized configuration and functional description of measuring instruments, generalized performance characteristics of instruments- static characteristics, dynamic characteristics, pressure measurement, flow measurements, temperature and heat flux measurements, data acquisition system, uncertainty analysis.

References:

1. Experimental methods for engineers by J. P. Holman, Tata McGraw Hill Book Company.
2. Mechanical Measurements by Thomas G. Beckwith and Lewis Buck, Narosa Publishing House.
3. Measurement System- Application and Design by O. D. Ernest, Tata McGraw Hill Book Company.

Mechanical Engineering Department

Course Code: **ME21363**
Course Name: **Optimization Methods in Engineering**

Introduction: Terminology, Design Variables, Constraints, Objective Function, Variable Bounds, Problem Formulation.
Linear Programming: Simplex Method, Duality in Linear Programming.
Single Variable Optimization Problems: Optimality Criterion, Bracketing Methods: Exhaustive Search Method, Bounding Phase Method, Region Elimination Methods: Interval Halving Method, Fibonacci Search Method, Golden Section Method, Successive Quadratic Estimation Method. Gradient Based Methods: Newton-Raphson Method, Bisection Method, Secant Method.
Multivariable Optimization Algorithms: Optimality Criteria, Unidirectional Search, Direct Search Methods: Box Method, Hooke-Jeeves Pattern Search Method, Powell's Conjugate Direction Method. Gradient Based Methods: Cauchy's Steepest Descent Method, Newton's method, Marquardt's Method, Conjugate Gradient Method, Variable-metric (DFP) Method.
Constrained Optimization Algorithms: Kuhn Tucker Conditions, Transformation Methods: Penalty Function Method, Method of Multipliers (MOM), Sensitivity Analysis.
Specialized Algorithms: Integer Programming: Penalty Function Method, Branch and Bound Method, Geometric Programming.
Non-Traditional Optimization Algorithms: Genetic Algorithms, Simulated Annealing, Tabu Search, Ant Colony Optimization, Particle Swarm Optimization.
Applications to Engineering Optimization Problems

References:

1. Kalyanmoy Deb, 2010.*Optimization for engineering design: algorithms and examples*. Prentice-Hall of India Private Limited, New Delhi
2. Kalyanmoy Deb, 2014.*Multi-Objective Optimization using Evolutionary Algorithms*. Wiley India Pvt. Ltd., New Delhi.
3. Singiresu S Rao, 2009. *Engineering optimization: theory and practice*. Fourth Edition, New Age International(P) Limited Publishers, New Delhi.
4. A. Ravindran, K. M. Ragsdell, G. V. Reklaitis, 2006. E*ngineering optimization - methods and applications*. Second Edition, John Wiley & Sons, Inc.

Mechanical Engineering Department

Course Code: **ME21364**
Course Name: **Alternative Fuels Technology**

Fossil fuels and their limitations: Introduction: Estimate of petroleum reserve, need for alternate fuel, and availability and comparative properties of alternate fuels.

Alternative fuels - Liquid and gaseous fuels, Physico-chemical characteristics, Alternative liquid fuels,Alternative gaseous fuels.

Alcohol fuels - Ethanol & methanol, Fuel composition, Fuel induction techniques, Fumigation, Emission of oxygenates, Applications to engines and automotive conversions.

Biodiesel: Formulation techniques, Transesterification, Application in diesel engines, Performance and emission characteristics,

Biomass: Broad classification, Production of biomass, Separation of components of solid wastes and processing techniques, Bioconversion into biogas, mechanism, Bioconversion of substrates into alcohols, Thermo chemical conversion of biomass, conversion to solid, liquid and gaseous fuels, case studies.

Other alternative fuels: DME (Dimethyl ether), LPG and PNG, CNG components, application to engine technology, mixtures and kits, fuel supply system and emission studies and control, **Hydrogen** combustion characteristics, Flashback control techniques, Safety aspects and system development

Hybrid vehicles: Theory and types Hybrid vehicle safety issues Special tools and equipment needed to diagnose and repair alternative vehicles

References:

1. Sunggyu Lee, James G. Speight, Sudarshan K. Loyalka “Handbook of Alternative Fuel Technologies”.
2. Gadepalli Ravi KiranSastry, “Bio-diesel: Bio-degradable Alternative Fuel for Diesel Engines”.
3. Michael F. Hordeski, “Alternative Fuels: The Future of Hydrogen”.
4. Maxwell et al, Alternative Fuel: Emission, Economic and Performance, SAE, 1995.
5. Watson, E.B., Alternative fuels for the combustion engine, ASME, 1990
6. Bechtold, R., Alternative fuels guidebook, 1998.

Mechanical Engineering Department

Course Code: **ME21365**
Course Name: **Engine Tribology**

Introduction: Introduction of Tribology, General tribological considerations in the design of bearings, gears, cams, reciprocating components.

Engine Tribology Basics: Tribological aspects of engine components such as bearings, piston assembly, valve train and drive train components.

Surface Properties: Surface properties of metals, composites, Surface texture measurement and assessment, statistical methods of surface texture assessment.

Friction: Theories of friction, Sliding friction – Rolling friction characteristics of common metals and non-metals – friction under different environments. Engine friction – Losses and engine design parameters.

Wear: Wear theories, types of wear and their mechanism, factors affecting wear, selection of materials for different wear situations, measurement of wear, tribometers and tribometry. Engine wear mechanisms, wear resistant materials and coatings and failure mode analysis.

Lubrication: Hydrodynamics, basic concepts, generalized Reynolds equation, slider bearings, fixed & pivoted shoe bearings, hydrodynamic journals bearings, short and finite bearings, thrust bearings, sintered bearing, non-circular bearings and multi side surface bearings. Hydrostatic bearing -basic concepts, bearing pads, flat, conical and spherical pad thrust bearing, multi-recess journal and thrust bearings, air and gas lubricated bearings.

Lubricants: Type of lubricants, properties and testing, service, classification of lubricants, lubrication of tribological components, lubrication system, lubricant monitoring, SOAP, ferrography and other rapid testing methods for lubricants contamination.

References:

1. Friction and Lubrication by Bowden F.P. & Tabor D., Heinemann Edu. Books Ltd. 1974
2. Friction & Wear of Material by Ernest Rabinowiez
3. Basic Lubrication Theory by A. Cameron, Ellis Horwood Ltd.
4. The principles of lubrication by A. Cameron, Longmans Green & Co. Ltd.
5. Theory and Practice of Lubrication for Engineers by D.D. Fuller, John Wiley and Sons
6. Tribology in Machine Design by T.A. Stolarski

Mechanical Engineering Department

Course Code: **ME21366**
Course Name: **Design of Cryogenic System**

Properties of engineering materials at cryogenic temperatures, mechanical properties ,thermal properties, electric & magnetic properties, super conducting materials ,thermo electric materials, composite materials, properties of cryogenic fluids, super fluidity of He 3 &He4.

Measurement systems for low temperatures:-Temperature measurements, pressure measurements, flow measurements, liquid level measurements, fluid quality measurements.

Cryogenic insulation:- various types such as expanded foams, gas filled& fibrous insulation, vacuum insulation, evacuated powder& fibrous insulation ,opacified powder insulation, multi layer insulation, comparison of performance of various insulations .
Applications of cryogenic systems Super conductive devices such as bearings, motors, cryotrons, magnets, D.C. transformers, tunnel diodes, space technology, space simulation, cryogenics in biology and medicine, food preservation and industrial applications, nuclear propulsions ,chemical propulsions.

Hazards:-Physical hazards, Chemical hazards, Physiological hazards, combustion hazards, oxygen hazards, , accidents in cryogenic plants & prevention

Safety in handling of cryogens, care for storage of gaseous cylinders, familiarization with regulations of department of explosives.

References:

1. Cryogenic systems-Baron, McGraw-Hill book
2. Cryogenic fundamentals-Haselden, Academic press New York
3. Advance cryogenic –bailey, plenum press

Mechanical Engineering Department

Course Code: **ME21367**
Course Name: **Gas Turbine and Jet Propulsion**

1 ***Review of gas dynamics:***Physical difference between incompressible, subsonic and supersonic flows Three reference speeds, dimensionless velocity concepts of static and stagnation parameters. Pressure waves, finite shock and detonation waves, compound waves, analysis of piston excited waves, shock tubes, one dimensional isentropic flow, normal shocks Rayleigh flow, fanno flow.

2 ***Gas turbine outlines*****:** Review of thermodynamic principles, Gas turbine cycles, main component of Gas turbine power plants, performance characteristics, typical Gas turbine plants, method of improving efficiency and power output of Gas turbine plants.

3 Design considerations of centrifugal and axial flow compressors.

4 Types of Gas turbine plants and their theory of operation, design consideration of Gas turbine plants. Detailed study of main systems of Gas turbine plants.

5 Selection of materials of Gas turbine components trouble shooting, maintenance and actual performance evaluation of a Gas turbine plants, recent development of a Gas turbine plants.

6 ***Jet propulsion outline*****:** Basic theory of jet & rocket propulsion devices and historical development. Types of various jet propulsion plants like air screw, turboprop, turbojet, ram jet, rocket propulsion etc. And their comparative study.

7 Performance study of various jet propulsion devices from ideal and practical consideration.

8 Study and design considerations of main components of jet propulsion plants. Thrust augmentation devices and their thermodynamic analysis.

9 Combustion performance, products at combustion and their properties, recent advances in jet propulsion and rocket propulsion devices.

References:

1. Gas dynamics by E.Rathakrishnan , Prentice-Hall of India, New Delhi
2. Compressible fluid flow by M.A. sand, Prentice-Hall, New Jersey
3. The Dynamics and Thermodynamics of Compressible Fluid Flow (2 volumes) by A.H Shapiro, Ronald Press, New York
4. Gas Turbine Fundamentals by Cohen, Rogers and Saravanmutto, Pearson Education.
5. Jet Propulsion by Jack D. Mattingly, McGraw Hill Inc.
6. Gas Turbine by V. Ganeshan, Tata-McGraw-Hill, New Delhi.

Mechanical Engineering Department

Course Code: **ME21368**
Course Name: **Design of Thermal Turbomachines**

Centrifugal compressors: Principle of operation, work done and pressure rise, Components of Centrifugal Compressor, Stage Pressure, Stage Efficiency, Degree Reaction, Dimensionless Parameters, Slip Factor, Causes of Slip, Velocity Triangles, Euler Work, Design of Impeller, Design of Diffuser, Design of Vane less Diffuser, Design of Volute Casing.

Axial flow compressors: Basic operation, elementary theory, factors affecting stage pressure ratio, blockage in the compressor annulus, degree of reaction, three-dimensional flow, design process, blade design, calculation of stage performance, compressibility effects, off-design performance, axial compressor characteristics, closure

Axial and radial flow turbines: Elementary theory of axial flow turbine, vortex theory, choice of blade profile, pitch and chord, estimation of stage performance, overall turbine performance, The cooled turbine, the radial flow turbine.

Prediction of performance of simple gas turbines: Component characteristics, off-design operation of the single-shaft gas turbine, equilibrium running of a gas generator, off-design operation of free turbine engine, off-design operation of the jet engine, methods of displacing the equilibrium running line, incorporation of variable pressure losses.

References:

1. Centrifugal compressors: A basic guide- M.P Boyce.
2. Gas turbine Theory- Cohen, Rogers
3. Axial flow compressors: A strategy for aerodynamic design and analysis - R. Aungier
4. Turbo Compressors and Fans – S.M. Yahya

Mechanical Engineering Department

Course Code: **ME21369**

Course Name: **Marine Engines and Propulsion**

Diesel engines, Gas Turbine, Steam turbines, Main Boilers, Feed systems, Pumps and pumping systems, Auxiliaries Fuel oils, lubricating oils and their treatment, Refrigeration, air conditioning and ventilation, Deck machinery and hull equipment. Marine shafting, gearing and propellers, Auxiliary system and machineries, Oil monitoring and propulsion, Steering gear, instrumentation and control.

References:

1. Basic Marine Engineering by T K Grover, Anmol Publisher Pvt Ltd.
2. Introduction to Marine Engineering by D. A. Taylor, Butterworth-Heinemann publications.
3. Marine Propellers and Propulsion by J S Carlton, Butterworth-Heinemann publications.
4. Marine Internal Combustion Engines by A. B Kane, Shroff Pub & Dist. Pvt. Ltd.

Mechanical Engineering Department

Course Code: **ME22370**
Course Name: **Design of Air Conditioning System**

Air Conditioning systems, Moist air systems and processes, applications of psychometrics to air-conditioning process, Indoor air quality, design comfort conditions, Heat transmission in buildings, conduction heat transfer through the building envelope, estimating heat loss or gain, Space heat loads, estimating heating requirements for a space or building, internal heat generation, Methods for estimating the space heat gains and the cooling loads, Energy calculations, Degree day concepts estimating seasonal energy costs, Pump and liquid system design, hot and steam heating systems, Space air diffusion, selection and location of air vents to space for optimal air movement, Fans and building air distribution systems, basics of sizing and selecting air handling equipment, Refrigeration equipment. Operation and control of vapor compression refrigeration systems

References:

1. Refrigeration and air-conditioning - C P Arora, Tata McGraw-Hill, 2nd edition, 2000.
2. ASHRAE (American Society of Heating, Refrigeration and Air-conditioning Engineers) Handbook.

Mechanical Engineering Department

Course Code: **ME22371**
Course Name: **Control of Automotive System**

Introduction: Overall demands, historic remark, perspectives

Thermodynamics Engine Cycles: Introduction to thermodynamics, first thermodynamic law, specific heat constant, state changes of ideal gases, thermodynamic cycles, ideal combustion engines, spark-ignited (SI) engine, diesel engine, comparison of different engine concepts, alternative combustion engines

Engine Management Systems: Basic engine operation, effective work, air-fuel ratio, engine concepts, inflammation of air-fuel mixtures, flame propagation, energy conversion, engine control, emissions of internal combustion engines, fuel measurement, intermittent fuel injection, injection time calculation, Air mass per combustion cycle, intake manifold dynamics, ignition angle control

Diesel Engine Modeling: Four stroke cycle diesel engine, charge exchange, flow into exhaust pipes, flow into combustion chamber, air-fuel ratio, exhaust stroke, intake stroke, compression and combustion, mass balance, fuel injection, fuel evaporation, cylinder dynamics, zero-dimensional modeling, thermodynamic equations, energy balance, volumetric work, heat losses, energy conversion, enthalpy of mass flows, internal energy of gas charge, calculation of state variables, fitting of model parameters, simulation results, soot accruement

Engine Control Systems: Basic control concepts, Lambda control, stoichiometric operation of SI engines, oxygen sensor, engine model for lambda control, lambda control circuit, measurement results, adaptive lambda control, idle speed control, energy conversion model and torque balance, state space control, measurement results, knock control, knocking at SI engines, knock sensors, signal processing, knock control, adaptive knock control, cylinder balancing, residues at stationary engine operation, residues at engine transients, adaptation of injection map

Diagnosis: Diagnosis of Automotive engines, why on-board diagnosis, OBDII, main characteristics, Introduction to diagnosis, basic definitions and concepts, model based diagnosis, some characteristics of model based diagnosis, faults, fault modeling, principles of model based diagnosis, residual generator design, residual evaluation, examples of model based diagnosis for SI engines, application examples – air intake system, modeling of air intake system, model identification, the diagnosis system, residual generation, residual evaluation, implementation, validation of the diagnosis system, misfiring detection, crankshaft moment of inertia, crankshaft torque balance, transformation into linear system representation, kalman filter design, results, engineering of diagnosis systems

References:

1. Automotive Control Systems- U. Kiencke Lars Nielsen, ISBN 3-540-23139-0 Springer, Berlin, Heidelberg, New York.
2. Internal Combustion Engine Fundamentals- J.B. Heywood, McGraw-Hill, ISBN: 9780070286375.
3. Engine Emissions Pollutant formation and advances in controlTecnology- B.P. Pundir,Nrosa, ISBN: 978-81-7319-819-9

Mechanical Engineering Department

Course Code: **ME22372**
Course Name: **Internal Combustion Engines and Pollution**

Engine types and their operation, Engine Design and operating parameters, Combustion Stoichiometry, Ideal models of Engine cycles

Gas Exchange: 4-Stroke, Gas Exchange: 2-Stroke, Mixture Preparation, Turbocharging Fuel Injection System in Diesel Engine, Charge motion within the cylinder, swirl, squish and tumble

Thermodynamic analysis of Spark-ignition Engine Combustion, Flame structure and speed, Cyclic variations in combustion, partial burning and misfire, Knock fundamentals

Types of diesel combustion systems, fuel spray behaviour, ignition delay, mixing controlled combustion

Introduction to Engine Emissions and air pollution, Genesis and formation of pollutants, Kinetics and modeling of thermal NO formation, Dependence of NO formation on temperature, Unburned hydrocarbon emissions, Flame quenching and Oxidation fundamentals, Adsorption desorption phenomenon, crevice effect on HC emissions, HC emission mechanism in diesel engine, CO formation Soot and Particulate formation, Soot inception, surface growth, Coagulation and Aggegation, NOx-Particulate trade-off, Effect of SI and CI engine design and operating variables on engine emission. Emission test procedures and regulations, Emission measurement: Instrumentation and methods, SI and CI engine Emission Control Technology, Catalytic converter, Exhauust gas recirculation, Diesel particulate filters, HCCI Engines.

Engine heat transfer, friction and lubrication, 2-Stroke and 4-Stroke Spark Engine Performance and Testing, Diesel Engine Performance and Testing, Engine operating characteristics, Alternative fuels.

References:

1. Internal Combustion Engine Fundamentals- J.B. Heywood, McGraw-Hill
2. Engine Emissions Pollutant formation and advances in controlTecnology- B.P Pundir, Nrosa
3. IC. Engine-V. Ganeshan, Tata McGraw-Hill
4. Fundamental of Internal combustion Engine- Z. Smith, Gill.
5. Internal Combustion Engine- W.W. Pulkrabek, Prentice Hall.

Mechanical Engineering Department

Course Code: **ME22373**
Course Name: **Computational Fluid Dynamics**

1 **Basic ideas of CFD:** Introduction to CFD, role of CFD and its applications, future of CFD. **Governing equations (GE's) of Fluid dynamics**: Modeling of flow, control volume concept, substantial derivative, physical meaning of the divergence of velocity. Continuity equation, momentum equation, energy equation and its conservation form. Equations for viscous flow (Navier-Stokes equations), equations for inviscid flow (Euler equation). Different forms of GE's, initial and boundary conditions.

2 **FVM for Diffusion Problems:** FVM for 1D steady state diffusion, 2D steady state diffusion, 3d steady state diffusion. Solution of discretised equations- TDMA scheme for 2D and 3D flows.

3 **FVM for Convection-Diffusion Problems:** FVM for 1D steady state convection-diffusion, Central differencing scheme, Conservativeness, Boundedness, Transportiveness, Upward differencing scheme, Hybrid differencing scheme for 2D and 3D convection-diffusion, Power-law scheme, QUICK scheme.

4 **Solution Algorithm for Pressure-velocity Coupling in Steady Flows:** Concept of staggered grid, SIMPLE, SIMPLER, SIMPLEC, PISO algorithm.

5 **FVM for Unsteady Flows:** 1D unsteady heat conduction (Explicit, Crank-Nicolson, fully implicit schemes), Implicit mecthods for 2D and 3D problems, Discretization of transient convection-diffusion problems, solution procedure for transient unsteady flow calculations (transient SIMPLE, transient PISO algorithms).

6 **Grid Generation:** General transformation of the equations. Metices and Jacobians. Types of grids- structured and unstructured grids, grid generation methods- algebraic, differential and hybrid methods. Coordinate stretching, boundary-fitted coordinate systems. Elliptic and hyperbolic grid generation methods, orthogonal grid generation for Navier-Stokes equations, Multi-block grid generation.

7 Latest development in CFD techniques and newer applications.

References:

1. An Introduction to Computational Fluid Dynamics: the Finite Volume Method by H.K.Versteeg and W. Malalasekara, Pearson Education, England
2. Computational Fluid Dynamics for Engineers by B. Andersson& others, 1st edition, Cambridge University Press, U.K.
3. Computational Fluid Flow and Heat Transfer" (2nd edition) by K. Muralidhar and T. Sundararajan, Narosa Publishing
4. Numerical Heat Transfer and Fluid Flow by S.V. Patankar, McGraw-Hill, New York
5. Principles of Computational Fluid Dynamics by P. Wesseling, Springer-Verlag.
6. Computational Techniques for Fluid Dynamics Volume I & II" (2nd edition) by C.A.J. Fletcher, Springer-Verlag,
7. Computational Fluid Mechanics and Heat Transfer" (2nd edition), J.C. Tannehill, D.A. Anderson and R.H. Pletcher, Taylor and Francis
8. Numerical Computation of Internal and External Flows (Vols. I & II) by C. Hirsch, Wiley International
9. Computational Fluid Dynamics for Engineers (Vols. I & II) by K. Hoffmann and S. T. Chiang, Engineering Education System

Mechanical Engineering Department

Course Code: **ME22374**
Course Name: **Exergy Analysis of Thermal Systems**

Exergy Destruction: Lost available work referred to heat engine cycle, refrigeration cycle, heat pump cycle, non-flow and steady flow processes, Mechanism of exergy destruction, modified Gouy-Stodola theorem, concept of effective temperature

Exergy Analysis of Simple Processes: Mixing and separation process of fluids of different temperature, heat transfer across a temperature difference, expansion and compression process, combustion process

Exergy Analysis of Power Plant Cycles: Maximum power subject to size constraint with fixed heat input and its application to Brayton cycle Steam turbine power plants: External and internal irreversibility, super heater, reheater, vacuum condenser, regenerative feed water heating, combined feed water heating and reheating Gas turbine power plant: External and internal irreversibility, regeration, reheater, and intercooler, combined steam and gas turbine power plant

Exergy analysis of Refrigeration cycle: Joule-Thomson Expansion, Work-Producing Expansion, Brayton Cycle, Optimal Intermediate Cooling, Exergy analysis of Air-conditioning applications: Mixtures of air and water vapour, total flow exergy of humid air & liquid water, Evaporative cooling process and other aspects

Exergy-economic Analysis: Fundamental of exergy-economics, exergy costing of different thermal components: steam or gas turbine, boiler, cogeneration system

Exergy analysis of renewable energy systems

References:

1. Advanced Engineering Thermodynamics by Adrian Bejan, John Wiley & Sons, Inc.
2. The Exergy Method of Thermal Plant Analysis by T J Kotas, Krieger Publishing Company.
3. Thermal Design and Optimization by Adrian Bejan, George Tsatsaronis, Michael Moran, John Wiley & Sons, Inc.
4. Advance Thermodynamics for Engineers by Winterbore D E, Arnold Publication
5. Advanced Thermodynamics for Engineers by Kenneth Wark, McGraw Hill Publishing Co. Ltd.
6. Fundamentals of Engineering Thermodynamics by Michel J Moran, Howard N Shapiro, Daisie D Boettner, Margaret B Bailey, John Wiley & Sons, Inc.
7. Exergy: Energy, Environment and Sustainable Development, I. Dincer, M.A. Rosen, 2nd edition, Elsevier.

Mechanical Engineering Department

Course Code: **ME22375**
Course Name: **Design and Analysis of Solar Energy Systems**

Introduction, Solar Radiation and its Measurement, Various Solar Energy Systems, Classification, Working principle of solar energy systems such as Solar water heater, Solar air heater, Solar distillation system, Solar passive house, Solar cooker, Solar aquaculture, Solar greenhouse system, Solar refrigeration and air-conditioning, Solar thermal power generation plant, Photovoltaics, Design of solar energy systems, Energy, Exergy analysis of solar energy systems, Enviro-economic analysis of solar energy systems.

References:

1. Solar Energy – Fundamentals, Design, Modeling & Applications by G.N. Tiwari, Narosa Publications.
2. Solar Energy Engineering by S. Kalogirou, Academic Press.
3. The Passive Solar House: The complete guide to heating and cooling your home by James Kachadorian , Chelsea Green Publishing
4. Solar Energy by Sukhatme and Nayak, Mcgraw Hill.
5. Solar Photovoltaics - Fundamentals, Technologies and Applications by C.S. Solanki, PHI
6. Solar Refrigeration by S. Kapil, Lambert Academic Publishing.
7. Solar Air-conditioning and Refrigeration by J. C. McVeigh and A. A. M. Sayigh , Pergamon Press

Mechanical Engineering Department

Course Code: **ME22376**
Course Name: **Energy System and Management**

Introduction: the energy-economy link, patterns of energy use in developed and developing countries, characteristics of conventional and renewable energy resources.

Efficient energy conversion through combined cycles, cogeneration and tri-generation systems. Energy conservation: energy auditing, bench marking, process energy and gross energy requirements, energy recovery in refrigeration and air-conditioning systems, mechanical vapor recompression systems. Energy conservation in buildings.

Environmental aspects of energy resource utilization: combustion generated air pollution, global warming, acid rain, fly ash disposal, radioactive pollution and nuclear waste disposal.

References:

1. Energy Systems and Sustainability by Godfrey Boyle et al, Oxford University Press
2. Energy efficiency by Eastop and Croft, Longman Scientific and Technical
3. Energy: Management, Supply and Conservation by Clive Beggs, Butterworth- Heinemann
4. www.bee-india.nic.in Bureau of Energy Efficiency, Ministry of Power, Government of India.

Mechanical Engineering Department

Course Code: **ME22377**
Course Name: **Fuels and Combustion Engineering**

Thermodynamics (1st & 2nd law for pure, non-reacting (mixture) and reacting systems; stoichiometry, thermo-chemistry, Clausius-Clapeyron equation etc.); Conservation Equations (Continuity, momentum, total & thermal energy and species); Fluid Mechanics; Heat Transfer & Mass Transfer.

Molecularity and order of reaction, Rates of reaction, Arrhenius equation. Conservation equations of mass, momentum, energy and species for a multicomponent system. Premixed and diffusion flames, Laminar and turbulent flames. Concepts of kinetically controlled and diffusion controlled reactions, Flammability limits, Ignition, Burning velocity, Flame structure and Stability for laminar flames.

Atomization of liquid, various atomizers and their performances Evaporation of droplets in high temperature gas streams, Simple model of droplet burning, Physical and mathematical models of spray flames.

Description of carbon sphere combustion, Diffusional theory of carbon combustion of pulverized coal.

Pollutant formation in various combustion processes and their controlling measures.

References:

1. An Introduction to Combustion: Concepts and Applications - S. R. Turns.
2. COMBUSTION: Fundamentals & Application - A. Datta, Narosa Publications.
3. Combustion Engineering - Gary L. Borman and K. W. Ragland.

Mechanical Engineering Department

Course Code: **ME22378**
Course Name: **Thermo-fluid Dynamics**

Review of Thermodynamic Laws and Entropy: Thermodynamic statements and their applications, Second law and their discussion, Equivalence of Kelvin-Planck and Clausius statements, Carnot engine and Carnot refrigeration, Thermodynamic temperature scale and absolute zero temperature, Clausius theorem and Clausius inequality, concept and characteristics of entropy, Principle of increase of entropy and entropy of universe.

Thermodynamic State Equations: Perfect and real gases, state equation of perfect gas, Amagat's isothermals, Detailed study of Van der Waal, Dieterio, Berthelot, Redlich and Kwong and other state equations for real gases, compressibility factor and compressibility chart, generalized chart.

Availability and Irreversibility: Available energy lost work and degradation of energy, Maximum work, Availability – in a closed system and in a steady flow system, Gibbs function, Helmholtz function, Irreversibility and its measurement.

Governing Equations: Continuity, Momentum and Energy Equations and their derivations in different coordinate systems, Boundary layer Approximations to momentum and energy.

Laminar External flow and heat transfer: (a) Similarity solutions for flat plate (Blasius solution), flows with pressure gradient (Falkner-Skan and Eckert solutions), and flow with transpiration, (b) Integral method solutions for flow over an isothermal flat plate, flat plate with constant heat flux and with varying surface temperature (Duhamel's method), flows with pressure gradient (von Karman-Pohlhausen method).

Laminar internal flow and heat transfer: (a) Exact solutions to N-S equations for flow through channels and circular pipe, Fully developed forced convection in pipes with different wall boundary conditions, Forced convection in the thermal entrance region of ducts and channels (Graetz solution), heat transfer in the combined entrance region, (b) Integral method for internal flows with different wall boundary conditions.

Natural Convection heat transfer: Governing equations for natural convection, Boussinesq approximation, Dimensional Analysis, Similarity solutions for Laminar flow past a vertical plate with constant wall temperature and heat flux conditions, Integral method for natural convection flow past vertical plate, effects of inclination, Natural convection in enclosures, mixed convection heat transfer past vertical plate and in enclosures.

References:

1. Engineering Thermodynamics by P. K. Nag.
2. Introduction to Thermodynamics by Y. V. C. Rao, New Age International (P) Ltd. Publishers, 1997.
3. Convective Heat and Mass Transfer by W. Kays, M. Crawford and B. Weigand, McGraw Hill International
4. Convection Heat Transfer by A. Bejan, John Wiley
5. Fundamentals of Heat and Mass Transfer by F.P. Incropera and D. Dewitt, John Wiley