APPLIED MATHEMATICS			
Course Code	20MTP11	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Error definition, round off errors and truncation errors. Mathematical modeling and Engineering problem solving: Simple mathematical model, Conservation Laws of Engineering. Vector and Tensor Analysis in Cartesian system, effect of rotation of coordinate systems.

Module-2

Roots of Equations: Graphical method, Bisection method, Newton- Raphson method, Secant Method. Simple fixed point iteration. Roots of polynomial-Polynomials in Engineering and Science, Muller's method, Bairstow's Method Graeffe's Roots Squaring Method

Module-3

Linear systems of algebraic equations: Gauss elimination, LU decomposition , Triangularization method, Cholesky Method, Partition method. Eigen values and Eigen Vectors: Bounds on Eigen Values, Jacobi method for symmetric matrices, Givens method for symmetric matrices, Householder's method for symmetric matrices, Rutishauser method for arbitrary matrices, Power method, Inverse power method.

Module-4

Solving ODE"s using: Picard's method, Runge-Kutta fourth order and Stiffness of ODE using shooting method. Solving PDE's by numerical method: one dimensional wave equation and heat equation

Module-5

Probability distributions: Binomial, Poisson. Normal. Sampling Theory: Testing of hypothesis for large and small samples, Goodness of fit. F-test, Analysis of Variance: One – way with/without interactions, problems related to ANOVA, Design of experiments

Course outcomes:

At the end of the course the student will be able to:

- Acquire the idea of significant figures, types of errors during numerical computation.
- Develop the mathematical models of thermal system using ODE's and PDE's.
- Learn the deterministic approach for statistical problems by using probability distributions.
- Classify and analyze mathematical tools applied to thermal engineering study cases.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

(1) C. Ray Wylie and Louis C Barrett, "Advanced Engineering Mathematics". 6th edition, McGraw-Hill, 1995.

(2) K Shankar Rao, "Introduction to Partial Differentia Equations" Prentice - Hall of India Pvt. Lt., 1995 Edition.

(3) S.S.Sastry, Introductory Methods of Numerical Analysis, PHI, 2005.

(4) Steven C Chapra and Raymond P Canale, "Numerical Methods for Engineers," 7th Ed., McGraw-Hill Edition, 2015.

Reference Books

(1) William W.H., Douglas C.M., David M.G. and Connie M.B., "Probability and Statistics in Engineering, 4th Edition, Willey Student edition, 2008.

(2) B.S. Grewal: Higher Engineering Mathematics, Khanna Publishers, 44th Ed., 2017

(3) M K Jain, S.R.K Iyengar, R K. Jain, Numerical methods for Scientific and engineering computation, New Age International, 2003.

(4) Pervez Moin, Fundamentals of Engineering Numerical Analysis, Cambridge, 2010.

FINITE ELEMENT METHOD IN HEAT TRANSFER

Course Code	20MTP12	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Introduction: Historical Perspective of FEM and applicability to Thermal Engineering problems. Conduction Heat Transfer and Formulation: Modeling heat conduction; formulation of governing equation, differential and Variational formulation. Initial, boundary and interface conditions. Approximate methods, Ritz and Galerkin's methods, Finite element approximation and basic concepts.

Module-2

Linear Steady state problems: Problems with one dimensional linear element, Formulation of element characteristic matrices and vectors. Assembly considerations and boundary conditions. Quadratic elements and their advantages and disadvantages. Two dimensional elements; triangular and quadrilateral elements, natural coordinates, parametric representation, Sub parametric, super parametric and Isoparametric elements. Formulation of conductive, convective matrices and nodal heat rate vectors. Analysis procedure for 2 D conduction with convection.

Module-3

Nonlinear Heat conduction Analysis: Galerkin's method to nonlinear transient heat conduction; Governing equation with initial and boundary conditions, one dimensional nonlinear steady-state problems and transient state problems.

Module-4

Viscous Incompressible Flows: Governing equations, weak form, finite element model, penalty finite element models, problems in two dimensional flow fields, finite element models of porous flow.

Module-5

Convective Heat Transfer: Basic equations, steady convection diffusion problems and transient convection-diffusion problems, Velocity-pressure-temperature formulation, Examples of heat transfer in a fluid flowing between parallel planes.

Course outcomes:

At the end of the course the student will be able to:

CO1: Establish the mathematical models for the complex analysis problems and predict the nature of solution.
CO2: Formulate the element characteristic for linear and nonlinear matrices and vectors.
CO3: Identify the boundary conditions and their incorporation in to the FE equations.
CO4: Solve the problems with simple geometries, with hand calculations involving the fundamental concepts.
CO5: Interpret the analysis results for the improvement or modification of the system.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

1. Reddy J.N.,Gartling. D.K., The Finite Element Method in Heat Transfer and Fluid dynamics, CRC
2. Lewis R.W., et al..The Finite Element method in Heat Transfer Analysis, John Wiley & Sons
3. Singiresu S.Rao, Finite element Method in Engineering, 5ed, Elsevier, 2012
4. Zeincowicz, The Finite Element Method, 4 Vol set. 4th Edition, Elsevier 2007.

Reference Books

1. Fundamentals of the finite element method for heat and fluid flow - R.W. Lewis, P. Nithiarasu and K. N. Seetharamu, , John Wileyand Sons, 2004.
2. The finite element method in heat transfer analysis - R.W. Lewis, K Morgan, H.R. Thomas, K.N. Seetharamu, John Wiley and Sons,1996

ADVANCED FLUID MECHANICS			
Course Code	20MTP13	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Introduction: Fluid Statics, Fundamental Equations-Applications of Fundamental Equations, Relative Motion of Liquids. Kinematics of Fluids- Review of basics-Velocity potential, Stream function and Vorticity. General theory of Stress and Rate of Strain Fundamental Equations – Integral form- Fundamental Equations – Integral form-Reynolds Transport Theorem-Applications of the Integral Form of Equations-Numerical.

Module-2

Mechanics of Laminar and Turbulent Flow: Introduction; Laminar and turbulent flows; viscous flow at different Reynolds number - wake frequency; laminar plane Poiseuille flow; stokes flow; flow through a concentric annulus. structure and origin of turbulent flow - Reynolds, average concept, Reynolds equation of motion; zero equation model for fully turbulent flows and other turbulence models; turbulent flow through pipes; losses in bends, valves etc; analysis of pipe network - Hard cross method.

Module-3

Exact and Approximate solutions of N-S Equations: Introduction; Parallel flow past a sphere; Oseen's approximation; hydrodynamic theory of lubrication; Hele-Shaw Flow.

Boundary Layer Theory: Introduction; Boundary layer equations; displacement and momentum thickness, shape factor; flow over a flat plate similarity transformation, integral equation for momentum and energy ; skin friction coefficient and Nusselt number; separation of boundary layer; critical Reynolds number; control of boundary layer separation.

Module-4

Flow across Normal Shock and Oblique Shock: Basic Equations Normal Shock – Prandtl-Meyer Equation, Oblique shock-Property variation – Relations and Tables-Numericals.

Module-5

Flow through a constant area duct with Friction: Flow through a constant area duct with Friction-FannoLine, Fanno Flow -Variation of Properties – Relations and Tables-Numericals. Flow through a constant area duct with Heat Transfer-Flow through a constant area duct with Heat Transfer-Rayleigh Line, Rayleigh Flow – Variation of Properties – Relations and Tables-Numericals.

Course outcomes:

At the end of the course the student will be able to:

CO1: Illustrate the basic concepts fluid flow and their governing equations

CO2: Analyse the laminar and turbulent flow problems.

CO3: Analyse one dimensional incompressible and compressible fluid flow Problems

CO4: Distinguish normal and oblique shocks and their governing Equations.

CO5: Describe the instruments and methods for flow measurements

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

(1) **Foundations of fluid mechanics -** S.W. Yuan, Foundations of Fluid Mechanics, Prentice Hall of India, 2000.

(2) White F.M., Viscous Fluid Flow, 3rd edition, Tata McGraw Hill Book Company, 2011.

Reference Books

(1) Introduction to fluid dynamics - Principles of analysis & design - Stanley Middleman, Wiley, 1997.

(2) S.M. Yahya, Fundamentals of Compressible Flow with Aircraft and Rocket Propulsion, 4th edition, New Age techno, 2010.

(3) Schlichting, H., Boundary Layer Theory, 8th edition, Springer, 2004.

COMBUSTION THERMODYNAMICS			
Course Code	20MTP14	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Introduction: Thermodynamics-equation of state, properties of gas mixtures, First law analysis of reacting systems, enthalpy of formation and heat of reaction, stoichiometric and equivalence ratio, adiabatic flame temperature. **Fuels and combustion**: Coal, fuel oil, natural and petroleum gas, emulsion firing, coal – oil and coal – water mixtures, synthetic fuels, bio-mass, combustion reactions, heat of combustion and enthalpy of combustion, theoretical flame temperature, free energy of formation, equilibrium constant, effect of dissociation. Combustion Mechanisms: Kinetics of combustion, mechanisms of solid fuel combustion, kinetic and diffusion control, pulverized coal firing system, fuel-bed combustion, fluidized bed combustion, coal gasifiers, combustion of fuel oil, combustion of gas, combined gas fuel oil burners, Requirements for efficient combustion , Recent trends in furnace /combustion chamber.

Module-2

Second law of thermodynamics and concept of chemical equilibrium: Gibbs free energy and the equilibrium constant of a chemical reaction (Vant-Hofts equation). Calculation of equilibrium Composition of a chemical reaction.

Module-3

Chemistry of Combustion: Basic Reaction Kinetics, Elementary reactions, Chain reactions, Multistep reactions, simplification of reaction mechanism, Global kinetics. **Physics of Combustion:** Fundamental laws of transport phenomena, Conservations Equations, Transport in Turbulent Flow.

Module-4

Premixed Flame: One dimensional combustion wave, Laminar premixed flame, Burning velocity measurement methods, Effects of chemical and physical variables on Burning velocity, Flame extinction, Ignition, Flame stabilizations, Turbulent Premixed flame

Module-5

Diffusion Flame: Gaseous Jet diffusion flame, Liquid fuel combustion, Atomization, Spray Combustion, Solid fuel combustion, Combustion and Environment: Atmosphere, Chemical Emission from combustion, Quantification of emission, Emission control methods.

Course outcomes:
At the end of the course the student will be able to:
CO1: Understand the basic thermodynamic concepts for combustion phenomena.
CO2: Describe the fuel energy conversion systems.
CO3: Apply the concept of flam flow mechanism in combustion process.
CO4: knowledge of adiabatic flame temperature in the design of combustion devices.
CO5: Identify the phenomenon of flame stabilization in laminar and turbulent flames.

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

(1) Mishra, D.P., Introduction to Combustion, Prentice Hall,2009
(2)Sharma, S. P., Fuels and Combustion, Tata McGraw Hill, New Delhi, 2001.
(3) Heywood Internal Combustion Engine Fundamentals, McGraw Hill Co.1988

Reference Books

(1) Thermodynamics – An Engineering Approach, Yunus Cengel and Michael Boles,7th Ed., Tata McGraw Hill
(2) Modern Engineering Thermodynamics, Robert Balmer, Elseveir.

(3)Advanced Thermodynamics for Engineers, Kenneth Wark, McGraw Hill
(4)Principles of Combustion, Kuo K. K., John Wiley and Sons.
(5)An Introduction to Combustion concepts and application by Stephen R. Turns, McGraw Hill Heigher Education, 2000.

ADVANCED POWER PLANT CYCLES

Course Code	20MTP15	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Analysis of Steam cycles: Rankine cycle, Carnot cycle, mean temperature of heat addition, effect of variation o steam condition on thermal efficiency of steam power plant, reheating of steam, regeneration, regenerative fee water heating, feed water heaters, carnotization of Rankine cycle, optimum degree of regeneration, Super critica pressure cycle, steam power plant appraisal, Deaerator, typical layout of steam power plant, efficiencies in a stean power plant, Cogeneration of Power and Process Heat, Numerical Problems. Combined cycle power generation Flaws of steam as working fluid in Power Cycle, Characteristics of ideal working fluid in vapor power cycle Binary vapor cycles, coupled cycles, combined cycle plants, gas turbine- steam turbine power plant, MHD-stean power plant, Thermionic- Steam power plant.

Module-2

Steam Generators: Basic type of steam generators, fire tube boilers, water tube boilers. Economizers, super heaters, re heaters, steam generator control, air preheater, fluidized bed boilers, electrostatic precipitator, fabric filters and bag houses, ash handling system, feed water treatment, de-aeration, evaporation, internal treatment, boiler blow down, steam purity, Numerical problems. Condenser, feed water and circulating water systems: Need of condenser, direct contact condensers, feed water heaters, circulating water system, cooling towers, calculations, Numerical Problems.

Module-3

Nuclear Power Plants: Chemical and nuclear reactions, nuclear stability and binding energy, radioactive decay and half-life, nuclear fission, chain reaction, neutron energies. Neutron flux and reaction rates, moderating power and moderating ratio, variation of neutron cross sections with neutron energy, neutron life cycle. Reflectors, Types of Reactor, PWR, BWR, gas cooled reactors. Liquid metal fast breeder reactor, heavy water and Fusion Power reactors. Safety in nuclear power plants.

Module-4

Hydro Electric Power Plant: Introduction, advantages and disadvantages of water power, optimization of hydro – thermal mix, hydrological cycles, storage and pondage Power plant Economics: Definitions, Principles, Location of power plant, cost analysis selection of type of generation, selection of power plant equipment’s

Module-5

Pollution and its effects: Definition, Cause, effects and control measures of - Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution and Nuclear hazards, Solid waste Management, Disaster management Role of an individual in prevention of pollution, Pollution case studies. **Social Issues and the Environment:** Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case Studies. Wasteland reclamation, Consumerism and waste products, Environment Protection Act, Air (Prevention and Control of Pollution) Act, Water (Prevention and control of Pollution) Act, Wildlife Protection Act, Forest Conservation Act, Issues involved in enforcement of environmental legislation.

Note: Visit to Power plant is desirable.

Course outcomes:
At the end of the course the student will be able to:
CO1: Distinguish the various power plant cycle and their working principles.
CO2: Describe the working principles of different components of power plant.
CO3: Explain the concepts of power generation by nuclear power plant.
CO4: Illustrate the concept of hydroelectric power generation.
CO5: Explain the concept of pollution and its effects.

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks
1. Power Plant Engineering - P.K. Nag, Tata McGraw-Hill Publications. 2nd edition
2. Power Plant Engineering - M.M. EI-Wakil, McGraw- Hill Publications. 1st edition
3. Power plant engineering –R.K.Rajput, Laxmi Publications 3rd edition

THERMAL ENGINEERING MEASUREMENT LABORATORY			
Course Code	20MTPL16	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	0:4:0	SEE Marks	60
Credits	02	Exam Hours	03

Sl.NO	Experiments
1	Develop a Diaphragm Gauge using steel diaphragm and electrical strain gauges mounted on the diaphragm to measure pressure of a gaseous source. Calibrate the gauge using a standard source of pressure. Enumerate the range of pressure measurement by such gauges and draw the calibration curves for loading and un-loading conditions
2	Develop manometers to measure pressure of gaseous sources of the order of 1 atm to 3 atm pressure. Choose proper size of glass tube, the multiple loops of tube and various manometric fluids to achieve the pressure ranges indicated. Also conduct the sensitivity test to assess the dynamic response of this gauge.
3	Develop a diaphragm Gauge with LVDT to measure low pressures. Calibrate the instrument against a standard pressure source of means and draw the calibration curves.
4	Design a venturimeter to measure the flow rate of a fluid of specific gravity 0.85 to measure flow rate up to 2 liters per second at atmospheric temperature of 30 degree centigrade. Use standard charts for determining the coefficient of discharge of venturimeter. Suppose the differential pressure gauge used to measure the pressure difference across the throat and convergent portion has an accuracy of 0.3 % of full scale, determine the percentage error of measurement of mass flow through the venturimeter at maximum flow rate.
5	Design a Rota meter to measure the flow rate of water with a maximum flow rate of 0.25 liters per second. Obtain the calibration curve for the scale fixed on the Rota meter for entire range of flow. Suppose a liquid of specific gravity 0.85 used instead of water, obtain the correction factor for the same.
6	Using a hot wire anemometer obtain the mean velocity profile in the test section of a laboratory wind tunnel and measure the turbulence intensity across the depth of the test section. The work should include the critical analysis of hot wire technique for measurement of velocity including design parameters and limitations of this technique.
7	Develop a shadowgraph and Schlieren to obtain the first order and second order density variation in the flow field. Using these techniques obtain the images of two fluid flow fields such as a jet of salt water flowing into distilled water, smoke coming out a insane-stick, thermal plumes raising from hot objects etc. Critical analysis of both techniques is a must.
8	Develop Mach-Zehnder interferometer and obtain the iso-temperature contours from a heated ball losing heat to ambient by natural convection. For these fringe lines obtained in free-convection boundary layers, obtain the expression for number of fringes and related density change in the temperature field.
9	For subsonic flows through an experimental wind tunnel, develop smoke visualisation technique and obtain the flow visualisation photographs for flow past a sharp edged flat plate at various angles of attack at different wind speeds and show the regimes of flow through photographs captured. Critical analysis of the image is essential to explain the phenomena of boundary layer separation.
10	Conduct a series of test to obtain the stagnation pressure response of pitot probe in a wind tunnel for varied yaw angle of the stagnation pitot and obtain the response curve in terms of error, (percentage of velocity head) to yaw angle. Repeat the experiment for other any two different type of stagnation pitot probes of various c/s and obtain the response curves for varying yaw angle. Critical analysis of curves obtained is desired.
11	Conduct a series of test to obtain the static pressure response of pitot probe in a wind tunnel for varied yaw angle of the static pitot and obtain the response curve in terms of error, (static percentage head) to yaw angle. Repeat the experiment for other any two different types of static pitot probes of different c/s and obtain the response curves for varying yaw angle. Critical analysis of curves obtained is desired.
12	Develop a simple constantan-iron or other suitable combination of thermocouple and calibrate it at freezing point and boiling point of water and draw the calibration curves. Integrate this instrument with a computer to log-in the data of changing temperature of a source and develop a code to obtain the temperature values which would automatically take care of changing atmospheric temperature for compensation of cold junction. Obtain the time constant of this thermocouple depending on the bead diameter of the tip of the thermocouple.
13	Develop a system to measure the thermal conductivity of liquid. Use either guarded hot-plate apparatus or concentric cylinder concept for the same. Develop the equations for determining the thermal conductivity of liquids. Using this instrument measure the thermal conductivity of water, alcohol and any liquid fuel.
14	Conduct performance test on IC engine and obtain the characteristic curves of mass flow of fuel to brake power (BP) at various operating loads and brake mean effective pressure (BMEP) show that for same BP and BMEP, two distinct values of mass flow of fuel is possible.

15	Conduct performance test on any IC engine and draw the conclusions on the effect of variation of load on the engine to its emission of pollution in terms of particulate matter (in case of diesel engine), CO, and NOX. Draw conclusions suitably.
16	Conduct performance test on any IC engine to evaluate the performance and emission characteristics of engine for various blends of bio-fuel with petroleum fuel and draw the conclusions. Critical analysis of performance and emission is essential.
17	Establish the effect of Exhaust Gas Recirculation (EGR) in IC engine to reduce the NOX formation. Draw the emission curves at various percentage of exhaust recirculation and also comment on the relative change in the performance of engine in terms of Brake Power

Note: Students are expected to do at least 07 Experiments (05 Experiments from Sl. No. 1-13 and 02 Experiments from Sl. No. 14-17)

Course outcomes:

At the end of the course the student will be able to:

CO1: Perform experiments to determine the coefficient of discharge of flow measuring devices.

CO2: Conduct experiments on hydraulic turbines and pumps to draw characteristics.

CO3: Test basic performance parameters of hydraulic turbines and pumps and execute the knowledge in real life situations.

CO4: Identify exhaust emission, factors affecting them and report the remedies.

CO5: Determine the energy flow pattern through the hydraulic machines and I C Engine

CO6: Exhibit his competency towards preventive maintenance of IC engines.

Reference Books

1. K L Kumar. “Engineering Fluid Mechanics” Experiments, Eurasia Publishing House, 1997.
2. Jagdish Lal, Hydraulic Machines, Metropolitan Book Co, Delhi, 1995
3. George E. Totten , Victor J. De Negri “Handbook of Hydraulic Fluid Technology, Second Edition, 2011.
4. E F Obert, Internal combustion engines and air pollution intext educational publishers (1973). 2. John Heywood, Internal combustion engine fundamentals, McGraw- Hill (1988) - USA.
5. Colin R Ferguson and Allan T. Kirkpatrick Internal combustion engines Applied Thermodynamics, John Wiley & sons – 2001.
6. Richard stone, Introduction to internal combustion engines, MacMillan (1992) – USA
7. M. L. Mathur And R.P. Sharma A course in internal combustion engines, Dhanpat Rai& sons- India.
8. C. F. Taylor The internal combustion engines in theory and practice, 2 vols. by: Wily.
9. C. F. Taylor The internal combustion engines in theory and practice, 2 vols. by:, pub.: Wily.
10. Ganesan, V., Fundamentals of IC Engines, Tata McGraw Hill, 2003 11. Bosch, Automotive hand book, 9th edition.
11. Measurement systems application and design by Ernest O. Doebelin, McGraw-Hill Science/Engineering/Math; 5 edition (November 28, 2003)

RESEARCH METHODOLOGY AND IPR			
Course Code	20RMI17	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	1:0:2	SEE Marks	60
Credits	02	Exam Hours	03

Module-1

Research Methodology: Introduction, Meaning of Research, Objectives of Research, Motivation in Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Importance of Knowing How Research is Done, Research Process, Criteria of Good Research, and Problems Encountered by Researchers in India.

Defining the Research Problem: Research Problem, Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem, An Illustration.

Module-2

Reviewing the literature: Place of the literature review in research, Bringing clarity and focus to your research problem, Improving research methodology, Broadening knowledge base in research area, Enabling contextual findings, How to review the literature, searching the existing literature, reviewing the selected literature, Developing a theoretical framework, Developing a conceptual framework, Writing about the literature reviewed.

Research Design: Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs, Important Experimental Designs.

Module-3

Design of Sampling: Introduction, Sample Design, Sampling and Non-sampling Errors, Sample Survey versus Census Survey, Types of Sampling Designs.

Measurement and Scaling: Qualitative and Quantitative Data, Classifications of Measurement Scales, Goodness of Measurement Scales, Sources of Error in Measurement Tools, Scaling, Scale Classification Bases, Scaling Technics, Multidimensional Scaling, Deciding the Scale.

Data Collection: Experimental and Surveys, Collection of Primary Data, Collection of Secondary Data, Selection of Appropriate Method for Data Collection, Case Study Method.

Module-4

Testing of Hypotheses: Hypothesis, Basic Concepts Concerning Testing of Hypotheses, Testing of Hypothesis, Test Statistics and Critical Region, Critical Value and Decision Rule, Procedure for Hypothesis Testing, Hypothesis Testing for Mean, Proportion, Variance, for Difference of Two Mean, for Difference of Two Proportions, for Difference of Two Variances, P-Value approach, Power of Test, Limitations of the Tests of Hypothesis.

Chi-square Test: Test of Difference of more than Two Proportions, Test of Independence of Attributes, Test of Goodness of Fit, Cautions in Using Chi Square Tests.

Module-5

Interpretation and Report Writing: Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports.

Intellectual Property: The Concept, Intellectual Property System in India, Development of TRIPS Complied Regime in India, Patents Act, 1970, Trade Mark Act, 1999,The Designs Act, 2000, The Geographical Indications of Goods (Registration and Protection) Act1999, Copyright Act,1957,The Protection of Plant Varieties and Farmers' Rights Act, 2001,The Semi-Conductor Integrated Circuits Layout Design Act, 2000, Trade Secrets, Utility Models, IPR and Biodiversity, The Convention on Biological Diversity (CBD) 1992, Competing Rationales for Protection of IPRs, Leading International Instruments Concerning IPR, World Intellectual Property Organisation (WIPO),WIPO and WTO, Paris Convention for the Protection of Industrial Property, National Treatment, Right of Priority, Common Rules, Patents, Marks, Industrial Designs, Trade Names, Indications of Source, Unfair Competition, Patent Cooperation Treaty (PCT), Advantages of PCT Filing, Berne Convention for the Protection of Literary and Artistic Works, Basic Principles, Duration of Protection, Trade Related Aspects of Intellectual Property Rights(TRIPS) Agreement, Covered under TRIPS Agreement, Features of the Agreement, Protection of Intellectual Property under TRIPS, Copyright and Related Rights, Trademarks, Geographical indications, Industrial Designs, Patents, Patentable Subject Matter, Rights Conferred, Exceptions, Term of protection, Conditions on Patent Applicants, Process Patents, Other Use without Authorization of the Right Holder, Layout-Designs of Integrated Circuits, Protection of Undisclosed Information, Enforcement of Intellectual Property Rights, UNSECO.

Course outcomes:

At the end of the course the student will be able to:

- Discuss research methodology and the technique of defining a research problem
- Explain the functions of the literature review in research, carrying out a literature search, developing theoretical and conceptual frameworks and writing a review.
- Explain various research designs, sampling designs, measurement and scaling techniques and also different methods of data collections.
- Explain several parametric tests of hypotheses, Chi-square test, art of interpretation and writing research reports
- Discuss various forms of the intellectual property, its relevance and business impact in the changing global business environment and leading International Instruments concerning IPR. ■

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbooks

(1) Research Methodology: Methods and Techniques, C.R. Kothari, Gaurav Garg,New Age International,4th Edition, 2018.

(2) Research Methodology a step-by-step guide for beginners. (For the topic Reviewing the literature under module 2), RanjitKumar,SAGE Publications,3rd Edition, 2011.

(3) Study Material (For the topic Intellectual Property under module 5),
Professional Programme Intellectual Property Rights, Law and Practice, The Institute of Company Secretaries of India, Statutory Body Under an Act of Parliament, September 2013.

Reference Books

(1) Research Methods: the concise knowledge base, Trochim, Atomic Dog Publishing, 2005.

(2) Conducting Research Literature Reviews: From the Internet to Paper, Fink A, Sage Publications, 2009.

*** END OF I SEMESTER ***

ADVANCED HEAT TRANSFER			
Course Code	20MTP21	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Introduction and one-dimensional heat transfer: The differential equation of heat conduction, heat generation, two dimensional steady state heat conduction, unsteady state processes, extended surfaces- fins of uniform cross section and non-uniform cross sections, Thermal resistance networks and applications. Numerical heat Transfer: Numerical techniques for solving heat conduction problems, the finite difference method for steady state situations, the finite difference method for unsteady state situations, Controlling Numerical Errors, problems.

Module-2

Thermal radiation: basic concepts and laws of thermal radiation, the shape factor, irradiant heat exchange in enclosures, black and Grey surfaces ,radiation shields and Radiation Effect on temperature measurements. Radiation properties of participating Medium, Emissivity and absorptivity of Gases and Gas Mixtures, Heat transfer from the Human Body problems.

Module-3

Analysis of Convection Heat Transfer: Boundary layer fundamentals evaluation of convection heat transfer coefficient, Analytical solution for laminar boundary layer flow over a flat plate, Approximate integral boundary layer analysis, Analogy between momentum and heat transfer in turbulent flow over a flat surface, Reynolds Analogy for Turbulent Flow Over Plane Surfaces, Mixed Boundary Layer, Special Boundary Conditions and High-Speed Flow.

Module-4

Natural and Forced convection: Introduction, Similarity Parameters for Natural Convection, Empirical Correlation for Various Shapes, Rotating Cylinders, Disks, and Spheres, Finned Surfaces Heat transfer by forced convection: Introduction, Analysis of Laminar Forced Convection in a Long Tube, Correlations for Laminar Forced Convection, Analogy Between Heat and Momentum Transfer in Turbulent Flow, Empirical Correlations for Turbulent Forced Convection, Heat Transfer Enhancement and Electronic-Device Cooling, Flow Over Bluff Bodies, Packed Beds, Free Jets. Cooling of electronic equipment.

Module-5

Heat exchangers: Basic concepts, types of heat exchangers, Analysis of heat exchangers, Counter-Flow Heat Exchangers, Multi pass and Cross-Flow Heat Exchangers, Use of a Correction Factor, Selection of Heat Exchangers such as Heat Transfer Rate, Cost, Pumping Power, Size and Weight, Type, Materials, Other Considerations, Compact Heat Exchangers. Heat Exchangers for multi-phase flow.

Note: 1. Industrial visit to R &AC plants is desirable.
2. A case study on Heat exchanger is desirable.

Course outcomes:

At the end of the course the student will be able to:

- **CO1:** Describe the different modes of heat transfer with both physics and the mathematical concept.
- **CO2:** Use the concepts of radiation heat transfer for enclosure analysis.
- **CO3:** Explain the concepts of Boundary layer.
- **CO4:** Formulate mathematical functions for two-dimensional and three dimensional heat conduction problems.
- **CO5:** Describe the free and forced convection problems in real time applications.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook/ Textbooks

(1)Heat Transfer – A Basic Approach - Ozisik M.N., McGraw-Hill Publications, 1st edition.

(2)Heat Transfer - Holmon J.P., McGraw-Hill Publications, 6th Edition.

(3)Principles of Heat Transfer - Frank Kreith,Thomson Publications, 7th Edition.

(4)Heat Transfer- A practical Aproach ,Yunus A CengelMcGraw-Hill Publications 2nd edition

STEAM AND GAS TURBINES			
Course Code	20MTP22	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03
Module-1			
Nozzles and diffusers: Introduction types of nozzles, types of Diffusers, Equation of Continuity Sonic Velocity and Mach Numbers, The Steady Flow Energy Equation in Nozzles, Gas Nozzles The Momentum Equation for the flow Through Steam Nozzles, Entropy Changes with friction, Nozzle Efficiency, The Effect of Friction on the Velocity of steam Leaving the Nozzles, Diffusion Efficiency, shape of Nozzle for Uniform Pressure Drop, Mass of Discharge of Critical Pressure in Nozzle Flow or Chocked Flow, Physical Explanation of Critical Pressure, Maximum Discharge of Saturated Steam, Maximum Discharge of Steam initially Superheated, Critical Pressure Ratio for Adiabatic and Frictionless Expansion of Steam from Ratio for Adiabatic and Frictionless Expansion of Steam from a given initial Velocity, Idea of Total or Stagnation Enthalpy and Pressure, General Relationship Between or Area Velocity and pressure in Nozzle Flow ,Effect of Friction on Critical Pressure Ratio Critical Pressure Ratio in a Frictionally Resisted Expansion from a Given Initial Velocity, Supersaturated Flow in Nozzles, Effect of Variation of Back Pressure, Parameters Affecting the Performance of Nozzles, Experimental Methods to Determine Velocity Coefficient, Experimental Results.			
Module-2			
Steam Turbines Types and Flow of Steam through Impulse Blades: Basic concepts, Principal of operation of turbine, Comparison of Steam Engines and Turbines, Classifications of Steam Turbine, Velocity Diagram for Impulse Turbines, Combination of Vector Diagram , Forces on the Blade and Work done by Blades, Blade or Diagram Efficiency ,Axial Thrust or end thrust on the rotor, Gross Stage Efficiency, Energy Converted heat by blade friction, Influence of ratio of blade speed to steam speed on blade efficiency in single stage impulse turbine, Efficiency of multistage impulse turbine with single row wheel, Velocity diagram for three row velocity compound wheel, Most economical ratio of blade speed for a two row velocity compounded impulse wheel, Impulse blade suctions, Choice of blade angle, Inlet blade angles, Blade heights in velocity compounded impulse turbine.			
Module-3			
Flow of Steam Through Impulse-Reaction Turbine Blades: Velocity diagram, degree of reaction, impulse-reaction turbine with similar blade section and half degree reaction turbine, height of reaction turbine blading, effect of working steam on the stage efficiency of Parson's turbine, operation of impulse blaring with varying heat drop or variable speed, impulse- reaction turbine section. State Point Locus Reheat Factor and Design Procedure: Introduction, stage efficiency of impulse turbines, state point locus of an impulse turbine, reheat factor, internal and other efficiencies, increase in isentropic heat drop in a stage due to friction in proceeding stage, correction for terminal velocity, reheat factor for an expansion with the uniform adiabatic index and a constant stage efficiency, correction of reheat factor for finite number of stages, design procedure of impulse turbine, design procedure for impulse- reaction turbines.			
Module-4			
Axial Flow and Centrifugal Compressors : Elementary theory, compressibility effects, factors affecting stage pressure ratio, blockage in compressor annulus, degree of reaction, 3-dimensional flow, design process and blade design, off design performance, compressor characteristics. Shaft power Cycles and Gas turbine cycles for Air-craft propulsion: Ideal cycles, methods of accounting for component cycles, design point performance calculations, comparative performance of practical cycles, COGAS cycles and cogeneration schemes, closed cycle gas turbines, simple turbojet cycle, turbo fan engine, turbo prop engine, thrust augmentation.			
Module-5			
Axial and Radial Flow Gas Turbines and Prediction of performance: Elementary theory of axial flow turbine, vortex theory, choice of blade profile, pitch and chord, estimation of blade performance, overall turbine performance, the tooled turbine, the radial flow turbine. 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. Energy losses in turbines: Valve, nozzle, blade, Trailing edge wake, impingement, leakage losses. Blade friction, turning of steam jet, blade wind age losses, losses due to shrouding, Disc friction ,radiation and conduction, mechanical losses, leakage through the end seals.			

Course outcomes:

At the end of the course the student will be able to:

CO1: Describe the working principles of Gas and steam turbines nozzle and diffusers.

CO2: Explain the principles of thermodynamic concept to determine the performance of steam and gas turbines.

CO3: Illustrate the concepts of axial flow and centrifugal compressors.

CO4: Differentiate axial flow and radial flow gas turbines for their analysis.

CO5: Identify the various losses associated with the turbines.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook/ Textbooks

1. **Steam and Gas Turbines -** R. Yadav, Central Publishing House, Allahabad.7th edition 2
2. **Gas Turbine Theory -** H.I.H. Saravanamuttoo, G.F.C. Rogers & H Cohen, Pearson Education.8th edition
3. **Gas Turbines -** V. Ganesan, Tata McGraw-Hill Publications.3rd edition
4. **Elements of Gas Turbine Propulsion-** Jack D Mattingley ,McGraw-Hill Publications 1st edition

REFRIGERATION AND AIR CONDITIONING			
Course Code	20MTP23	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Refrigeration cycles – 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.

Module-2

Refrigerants: Classification of Refrigerants, Refrigerant properties, Oil Compatibility, Environmental Impact-Montreal/ Kyoto protocols-Eco Friendly Refrigerants. Different Types of Refrigeration Tools, Evacuation and Charging Unit, Recovery and Recycling Unit, Vacuum Pumps. Other refrigeration cycles: Vapor Absorption Systems-Aqua Ammonia & LiBr Systems, Steam Jet Refrigeration Thermo Electric Refrigeration, Air Refrigeration cycles.

Module-3

Psychrometry: Moist Air properties , use of Psychrometric Chart, Various Psychrometric processes, Air Washer , Adiabatic Saturation. Summer and winter air conditioning: Air conditioning processes-RSHF, summer Air conditioning, Winter Air conditioning, and Bypass Factor. Applications with specified ventilation air quantity-Use of ERSHF, Application with low latent heat loads and high latent heat loads,

Module-4

Load estimation & air conditioning control: Solar Radiation-Heat Gain through Glasses, Heat transfer through roofs and walls, Total Cooling Load Estimation. Controls of Temperature, Humidity and Airflow.

Module-5

Air distribution: Flow through Ducts, Static & Dynamic Losses, Air outlets, Duct Design–Equal, Friction Method, Duct Balancing, Indoor Air Quality, Thermal Insulation, Fans & Duct System Characteristics, Fan Arrangement Variable Air Volume systems, Air Handling Units and Fan Coil units. Central air condition systems.

Course outcomes:

At the end of the course the student will be able to:

CO1: Understand concepts of refrigeration and air-conditioning process and systems.

CO2: Employ the theoretical principles to simple, complex vapour compression and vapour absorption refrigeration systems.

CO3: Understand conventional and alternate refrigerants and their impact on environment.

CO4: Apply the heat load calculation to design the air-conditioning systems.

CO5: Describe the concepts to design air distribution systems.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook/ Textbooks

1. Roy J. Dossat, Principles of Refrigeration, Wiley Limited 2002

2.Arora C.P., Refrigeration and Air-conditioning, 3rdedition,Tata McGraw –Hill, New Delhi 2008

3.Stoecker W.F., and Jones J.W., Refrigeration and Air-conditioning, 2nd edition McGraw - Hill, New Delhi

4.Data Books: Refrigerant and Psychrometric Properties (Tables & Charts) SI Units, Mathur M.L. & Mehta F.S., Jain Brothers. 2010.

Reference Books	
1.	Principles and Refrigeration- Goshnay W.B., Cambridge, University Press, 1985.
2.	Solid state electronic controls for HVACR' -Langley, Billy C., 'Prentice-Hall 1986
3.	Handbook of Air Conditioning Systems design- Carrier Air Conditioning Co., McGraw Hill,
4.	Refrigeration and Air Conditioning (3/e) - Langley Billy C., Engie wood Cliffs (N.J) PHI.
5.	Fundamentals and equipment- 4 volumes-ASHRAE Inc. 2005.
6.	Air Conditioning Engineering-Jones, Edward Amold pub. 2001.

ENERGY CONSERVATION AND MANAGEMENT			
Course Code	20MTP241	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Energy Conservation: Introduction - Indian Energy Conservation Act - List of Energy Intensive Industries - Rules for Efficient Energy Conservation - Identification of Energy Conservation opportunities - Technologies for Energy Conservation – Energy Conservation Schemes and Measures - Energy flow networks - Critical assessment of energy use - Optimizing Energy Inputs and Energy Balance - Pinch Technology.

Module-2

Energy Efficiency Improvement: Steam Generation - Distribution and Utilization –Furnaces - Fans and Blowers - Compressors Pumps - Pinch Technology - Fluidized bed Combustion - Heat Exchanger Networks - Case Studies - Analysis and recommendation.

Module-3

Energy Audit: Definition and Concepts, Types of Energy Audits – Basic Energy Concepts –Energy audit questionnaire, Data Gathering – Analytical Techniques. Energy Consultant: Need of Energy Consultant – Consultant Selection Criteria, Economic Analysis: Scope, Characterization of an Investment Project – Types of Depreciation –Time Value of money – budget considerations, Risk Analysis. Introduction to SCADA software.

Module-4

Energy Efficient Lighting: Terminology - Laws of illumination - Types of lamps -Characteristics - Design of illumination systems - Good lighting practice - Lighting control- Steps for lighting energy conservation. Lighting standards.

Module-5

Economics of Generation and Distribution: Generation: Definitions - Connected load, Maximum demand - Demand factor –Diversity factor – Significance - Power Factor – Causes and disadvantages of low power factor – Economics of power factor improvement. Distribution: Electrical load analysis - Types of consumers & tariffs - Line losses -Corona losses - Types of distribution system - Kelvin’s law - Loss load factor – Green Labeling – Star Rating.

Course outcomes:

At the end of the course the student will be able to:

- **CO1:** Understand the various energy conservation and improvement techniques.
- **CO2:** Illustrate the Energy scenario.
- **CO3:** Employ the principles of thermal engineering and energy management to improve the Performance of thermal systems.
- **CO4:** Assess energy projects on the basis of economic and financial criteria.
- **CO5:** Describe methods of energy production for improved utilization

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook/ Textbooks

1. Turner, W. C., Doty, S. and Truner, W. C., Energy Management Hand book, 7th edition, Fairmont Press, 2009.
2. De, B. K., Energy Management audit & Conservation, 2nd Edition, Vrinda Publication, 2010.
3. Murphy, W. R., Energy Management, Elsevier, 2007.
4. Smith, C. B., Energy Management Principles, Pergamon Press, 2007

THERMAL POWER STATION			
Course Code	20MTP242	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Steam Generator and Auxiliaries: High pressure boilers, classification, schemes¸ circulation, nature of fuels and its influence on design, furnaces, PF burners, PF milling plant, oil and gas burner types and location, arrangement of oil handling plant. Waste heat recovery systems. Operation and Maintenance of Steam Generators and auxiliaries: Pre commissioning activities, Boiler start up and shut down procedures, emergencies in boiler operation, Maintenance of Steam generator and auxiliaries.

Module-2

Dust Extraction Equipment: Bag house, electrostatic precipitator, draught systems, FD, ID and PA fans, chimneys, flue and ducts, dampers, thermal insulation and line tracing, FBC boilers and types., waste heat recovery boilers.

Module-3

Feed Water system: Impurities in water and its effects, feed and boiler water corrosion, quality of feed water, boiler drum water treatment and steam purity, water treatment, clarification, demineralization, evaporation and reverse osmosis plant. Circulating water system: Introduction, System classification, The circulation system, Wet-Cooling towers, Wet-cooling tower calculations, Dry cooling towers, Dry-cooling towers and plant efficiency and economics, wet-dry cooling towers, cooling-tower icing, Cooling lakes and ponds, Spray ponds and canals.

Module-4

Performance: Boiler efficiency and optimization, coal mill, fans, ESP. EIA study: Pollutants emitted, particulate matter, SOx and NOx and ground level concentration, basic study of stack sizing.

Module-5

Miscellaneous of steam power plant: Methods of loading, plant selection, arrangements, useful life of plant components, pumps, cost estimation steam power plant, comparison of different power plants, current scenario of thermal power generation in India, Indian boiler act and amendments, case studies.

Course outcomes:

At the end of the course the student will be able to:

- **CO1:** Describe the working principle, operation and maintenance of a various steam generators.
- **CO2:** Identify the arrangements of different flow systems their operation and maintenance.
- **CO3**: Illustrate the impact of thermal power plant exhaust on environment.
- **CO3:** Estimate the working expenses, current scenario and trends in power generation.
- **CO4:** Asses the performance and suitability of thermal power plant.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Reference Books

1. **Power Plant Engineering -** P.K. Nag, Tata McGraw-Hill Publications. 2nd edition
2. **Power Plant Engineering -** M.M. EI-Wakil, McGraw- Hill Publications. 1st edition
3. **Power plant engineering –**R.K.Rajput ,Laxmi Publications 3rd edition

NUCLEAR ENGINEERING IN POWER GENERATION			
Course Code	20MTP243	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Introduction to Nuclear Physics: Motivation for nuclear energy, Nuclear model of the atom, Equivalence of mass and energy, Binding energy, Mechanism of nuclear fission and fusion, Radio activity, Half-life, Radiation interactions with matter, Cross sections, Principles of Radiation detection, Decay Heat. **Nuclear Fuel Cycle:** Uranium exploration, mining, Uranium production, Ffuel fabrication, Spent fuel handling, Reprocessing (Purex, Urex, Diamex), Pyro processing, Fuel transportation between facilities, Radioactive waste management: Types, treatment, compaction, Vitrification etc., Materials: Fuel, Structural, Coolants, Control, Moderator, Shielding.

Module-2

Types of Nuclear Reactors: Components of a nuclear reactor, Types of nuclear reactors, Pressurized Water Reactor, Boiling water Reactor, Pressurized Heavy Water Reactor, Gas Cooled reactor, Liquid Metal cooled fast breeder reactors, Gen IV Concepts.

Module-3

Thermal Power Reactors: Layout of nuclear power plant; Zoning requirements: layout in the reactor building; Material selection for components, Operating environment. Zone control, Regulating rods, Absorbers, Shutdown systems. Fuel and Fuel transfer system; Primary heat Transport System; Emergency core cooling system; Moderator system; Auxiliary System.

Module-4

Fast Power Reactors: Breeding ratio, Doubling time, Core design features - Static and Dynamic, control rod design, Shielding principles, Fuel management, and safety. Core & important design parameters, Comparison of core components, Major primary and secondary system components. Description, choice of core materials, engineering design of core, High temperature design methods. Decay heat removal system. Instrumentation & control.

Module-5

Reactor Thermal Hydraulics: Heat Transfer in Fuel, Fuel to coolant, One dimensional heat conduction with heat generation, Heat Transfer properties of water, gas, liquid metals, Correlations, Pressure drop: Single Phase, Two Phase, Instability of two phase flow, Basic Carnot, Rankine and Brayton Cycles.

Course outcomes:

At the end of the course the student will be able to:

- **CO 1:** Understand the basic physics of nuclear reactions
- **CO 2:** Basic concepts of nuclear fuel manufacturing and spent fuel handling
- **CO 3:** Classification of nuclear reactors
- **CO 4:** Understand working principle of thermal reactor
- **CO 6:** Analyse the thermal hydraulics of nuclear reactors

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook/ Textbooks

1. Nuclear Reactor Engineering-Concepts & Principles - G. Vaidyanathan, S. Chand co., Delhi, 2013.
2. Nuclear Reactor Engineering (3rd Edition) - S. Glasstone and A.Sesonske, Von Nostrand, 1981.

Reference Books

1. Comprehensive Nuclear Materials- Rudy J.M. Konings, vol. 1-5, Elsevier Ltd, 2012
2. Nuclear Power Plant Instrumentation and Control Systems for Safety and Security-M. Yastrebenetsky, V. Kharchenko, , February 2014.
3. Fast Breeder Reactor- A.E.Walter and A.B.Reynolds, Pergamon Press, 1981
4. Fundamentals of Nuclear Reactor Physics-E. Lewis, Academic Press, 2008

CRYOGENICS

Course Code	20MTP244	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Introduction: Cryogenics and its applications, Cryogenic Fluids, Properties of cryogenic fluids, Properties of materials at cryogenic temperature. Gas Liquefaction and Refrigeration Systems: Basics of Refrigeration/Liquefaction, Production of low temperatures, Ideal thermodynamic cycle and Various liquefaction cycles: Linde–Hampson system, Linde Dual –Pressure System, Claude System, Kapitza System, Heylandt System and Collins System.

Module-2

Gas Separation: Basics of Gas Separation, Ideal Gas Separation System, Properties of Mixtures and the Governing Laws, Principles of Gas Separation, Rectification and Plate Calculations. **Cryocoolers:** Classification and application of Cryocooler, Recuperative Cryocoolers, Regenerative Cryocoolers, J-T Cryocooler, Stirling Cryocooler, G-M Cryocooler and Pulse Tube Cryocooler.

Module-3

Vacuum Technology: Need of Vacuum in Cryogenics, Vacuum fundamentals, Conductance and Electrical analogy, Pumping Speed and Pump down time and Vacuum Pumps.

Module-4

Instrumentation in Cryogenics: Need of Cryogenic Instrumentation, Measurement of Thermo-physical Properties and Various Sensors.

Module-5

Cryogenic Insulations: Importance of Cryogenic insulation, Types of Cryogenic insulations and application **Safety in Cryogenics** Need for Safety, basic hazards and protection from hazards.

Course outcomes:

At the end of the course the student will be able to:

- **CO1:** Understand the working principles and applications of different types of gas liquefaction and refrigeration systems.
- **CO2:** Understanding the governing laws and principles of gas separation.
- **CO3:** Study on cryocoolers and its applications.
- **CO4:** Understanding the importance of cryogenics insulations and Safety in Cryogenics.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook/ Textbooks

1. Randall F. Barron, "Cryogenics Systems", Second Edition Oxford Univesity Press New
2. Timmerhaus, Flynn, "Cryogenics Process Engineering", Plenum Press, New York.
3. Pipkov, "Fundamentals of Vacuum Engineering", Meer Publication.

Reference Books

1. G.M Walker. "Cryocooler-Part 1 Fundamentals" Plenum Press, New York and London.
2. G.M Walker. "Cryocooler-Part 2" Plenum Press, New York and London.

SOLAR THERMAL TECHNOLOGIES AND ITS APPLICATIONS

Course Code	20MTP251	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Solar Radiation: Location on earth, celestial sphere, horizon and equatorial system, Instruments for measuring solar radiation and sunshine, description of the various angles depicting the relation between sun and earth, coordinates transformation, solar time, obliquity and declination of the sun, apparent motion of the sun, sun rise and sun set time, east west time, analysis of the direct daily solar radiation on any arbitrarily located surface.

Module-2

Flat Plate Collectors: Performance analysis, transmissivity of the cover system, overall loss coefficient and heat transfer correlations, collector efficiency factor, collector heat removal factor, effects of various parameters on the performance. Evacuated Tube Collectors Principle of working, advantages of ETC over FPC, Types of evacuated tubes. Design aspects of solar plate collectors.

Module-3

Concentrating Collectors: Types, description of cylindrical parabolic collector, orientation and tracking modes, performance analysis, parametric study of collector performance in different modes of operation, compound parabolic collector geometry, tracking requirements, parabolic dish collector.

Module-4

Thermal Energy Storage: Introduction, sensible heat storage: liquids, solids, analysis of liquid storage tank in well mixed condition and thermal stratification, analysis of packed-bed storage, latent heat storage, thermo chemical storage.

Module-5

Applications: Water heating systems (Natural and Forced), Industrial process heating system, Active and passive space heating, Solar absorption refrigeration, Power generation (Low Temperature, Medium Temperature, High Temperature), Distillation, Drying, Cooking, Solar Pond. Recent advancement in materials and systems for thermal energy storage systems.

Course outcomes:
At the end of the course the student will be able to:

- CO 1 Analyse the energy concepts on solar devices for various thermal properties.
- CO 2 Analyse the solar thermal devices for various tracking modes.
- CO 3 Evaluate the performance of various solar thermal technologies.

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook/ Textbooks

1. S.P. Sukhatme, J K Nayak “Solar Energy- Principles of Thermal Collection and Storage”, Tata McGraw Hill
2. G. D. Rai., “Non- Conventinal Energy Sources”, Khanna Publishers, NewDelhi

Reference Books

1. G.N. Tiwari and S. Suneja, Solar Thermal Engineering Systems, Narosa Publishers.
2. Khan, B.H., “Non-Conventional Energy Resources”, Tata McGraw Hill, 2nd Edition, New Delhi.
3. Recent Advancements in Materials and Systems for Thermal Energy Storage, Dott. Andrea Frazzica, Prof. Luisa F. Cabeza, ISBN 978-3-319-96639-7

MODELING AND SIMULATION OF THERMAL SYSTEMS			
Course Code	20MTP252	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Principle Of Computer Modeling And Simulation: Monte Carlo simulation, Nature of computer modeling and simulation, limitations of simulation, areas of application. **System and Environment:** components of a system-discrete and continuous systems. Models of a system-a variety of modeling approaches.

Module-2

Random Number Generation: technique for generating random numbers —mid squad e method- The mid product method- constant multiplier technique-additive congruential method- linear congruential method —tests for random number s —the kolmogorov-simrnov test-the Chi-square test. **Random Variable Generation:** inversion transforms technique- exponential distribution- uniform distribution-weibul distribution empirical continuous distribution- generating approximate normal variants-Erlang distribution.

Module-3

Empirical Discrete Distribution: Discrete uniform distribution—poisson distribution geometric distribution-acceptance-rejection technique for poission distribution-gamma distribution. **Design And Evaluation Of Simulation Experiments**: variance reduction techniques-antithetic variables- variables-verification and validation of simulation models.

Module-4

Discrete Event Simulation: concepts in discrete-event simulation, manual simulation using event scheduling, single channel queue, two server queue simulation of inventory problem.

Module-5

Introduction to GPSS: Programming for discrete event systems in GPSS, case studies.

Course outcomes:

At the end of the course the student will be able to:

- CO1: Explain the basic principles and concepts underlying in modeling and simulation Techniques.
- CO2: Optimize the design of thermal systems.
- CO3: Develop representational modes of real processes and systems.
- CO4: Generate suitable modelling techniques to compute the performance.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook/ Textbooks

1. Discrete event system simulation - Jerry Banks & John S Carson II, prentice hall Inc, 1984.
2. Systems simulation - Gordon g, prentice Hall of India Ltd, 1991.
3. System simulation with digital Computer - NarsinghDeo, Prentice Hall of India, 1979.
4. Thermal Power Plant Simulation & Control - D. Flynn (Ed), IET, 2003.

COMPUTATIONAL METHODS IN HEAT TRANSFER & FLUID FLOW			
Course Code	20MTP253	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Introduction: History and Philosophy of computational fluid dynamics, CFD as a design and research tool, Applications of CFD in engineering, Programming fundamentals, MATLAB programming, Numerical Methods. Governing equations of fluid dynamics: Models of the flow, The substantial derivative, Physical meaning of the divergence of velocity, The continuity equation, The momentum equation, The energy equation, Navier-Stokes equations for viscous flow, Euler equations for inviscid flow, Physical boundary conditions, Forms of the governing equations suited for CFD, Conservation form of the equations, shock fitting and shock capturing, Time marching and space marching.

Module-2

Mathematical behavior of partial differential equations: Classification of quasi-linear partial differential equations, Methods of determining the classification, General behavior of Hyperbolic, Parabolic and Elliptic equations. **Basic aspects of discretization**: Introduction to finite differences, Finite difference equations using Taylor series expansion and polynomials, Explicit and implicit approaches, Uniform and unequally spaced grid points. **Grids with appropriate transformation**: General transformation of the equations, Metrics and Jacobians, The transformed governing equations of the CFD, Boundary fitted coordinate systems, Algebraic and elliptic grid generation techniques, Adaptive grids.

Module-3

Parabolic partial differential equations: Finite difference formulations, Explicit methods – FTCS, Richardson and DuFort-Frankel methods, Implicit methods – Laasonen, Crank-Nicolson and Beta formulation methods, Approximate factorization, Fractional step methods, Consistency analysis, Linearization**. Stability analysis**: Discrete Perturbation Stability analysis, von Neumann Stability analysis, Error analysis, Modified equations, artificial dissipation and dispersion.

Module-4

Elliptic equations: Finite difference formulation, solution algorithms: Jacobi -iteration method, a Gauss- Siedel iteration method, point- and line-successive over-relaxation methods, and alternative direction implicit methods. **Hyperbolic equations**: Explicit and implicit finite difference formulations, splitting methods, multi-step methods, applications to linear and nonlinear problems, linear damping, flux corrected transport, monotone and total variation diminishing schemes, tvd formulations, entropy condition, first-order and second-order tvd schemes.

Module-5

Scalar representation of Navier-stokes equations: Equations of fluid motion, numerical algorithms: FTCS explicit, FTBCS explicit, Dufort-Frankel explicit, Maccormack explicit and implicit, BTCS and BTBCs implicit algorithms, applications. **Grid generation:** Algebraic Grid Generation, Elliptic Grid Generation, Hyperbolic Grid Generation, Parabolic Grid Generation. **Finite volume method for unstructured grids:** Advantages, Cell Centered and Nodal point Approaches, Solution of Generic Equation with tetrahedral Elements, 2-D Heat conduction with Triangular Elements Numerical solution of quasi one-dimensional nozzle flow: Subsonic-Supersonic isentropic flow, Governing equations for Quasi 1-D flow, Non-dimensionalizing the equations, MacCormack technique of discretization, Stability condition, Boundary conditions, Solution for shock flows

Course outcomes:

At the end of the course the student will be able to:

- **CO1:** To derive the stepwise procedure to completely solve a fluid dynamics problem using computational methods.
- **CO2:** To explain the governing equations and understand the behaviour of the equations.
- **CO3:** To determine the consistency, stability and convergence of various discretization schemes for parabolic, elliptic and hyperbolic partial differential equations.
- **CO4:** To verify variations of SIMPLE schemes for incompressible flows and Variations of Flux Splitting algorithms for compressible flows.
- **CO5:** To identify various methods of grid generation techniques and application of finite difference and finite volume methods to various thermal problems.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook/ Textbooks

1. Numerical Heat Transfer and Fluid Flow - S.V. Patankar, Hemisphere Publishing Company.
2. Computational Fluid Dynamics - T.J. Chung, Cambridge University Press 2003
3. Computational fluid flow and heat transfer - K. Murlidhar and T. Sounderrajan, Narosa Publishing Co.
4. Computational fluid mechanics and heat transfer - D. A. Anderson, J. C. Tannehill, R.H. Pletcher, Tata McGraw-Hill Publications 2002
5. Computational fluid dynamics - J.A. Anderson, McGraw-Hill Publications 1995
6. An Introduction to Computational Fluid DynamicsVersteeg, H.K. and Malalasekara, W, Pearson Education, 2010

JET PROPULSION AND ROCKETRY			
Course Code	20MTP254	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

PRINCIPLES OF JET PROPULSION AND ROCKETRY: Fundamentals of jet propulsion, Rockets and air breathing jet engines – Classification – turbo jet , turbo fan, turbo prop, rocket (Solid and Liquid propellant rockets) and Ramjet engines. Nozzle Theory and Characteristics Parameters: Theory of one dimensional convergent – divergent nozzles – aerodynamic choking of nozzles and mass flow through a nozzle – nozzle exhaust velocity – thrust, thrust coefficient, Ac / At of a nozzle, Supersonic nozzle shape, non-adapted nozzles, summer field criteria, departure from simple analysis – characteristic parameters – 1) characteristic velocity, 2) specific impulse 3) total impulse 4) relationship between the characteristic parameters 5) nozzle efficiency, combustion efficiency and overall efficiency.

Module-2

AERO THERMO CHEMISTRY OF THE COMBUSTION PRODUCTS: Review of properties of mixture of gases – Gibbs – Dalton laws – Equivalent ratio, enthalpy changes in reactions, heat of reaction and heat of formation – calculation of adiabatic flame temperature and specific impulse – frozen and equilibrium flows. Solid Propulsion System: Solid propellants – classification, homogeneous and heterogeneous propellants, double base propellant compositions and manufacturing methods. Composite propellant oxidizers and binders. Effect of binder on propellant properties. Burning rate and burning rate laws, factors influencing the burning rate, methods of determining burning rates

Module-3

SOLID PROPELLANT ROCKET ENGINE: internal ballistics, equilibrium motor operation and equilibrium pressure to various parameters. Transient and pseudo equilibrium operation, end burning and burning grains, grain design. Rocket motor hard ware design. Heat transfer Thermal Engineering considerations in solid rocket motor design. Ignition system, simple pyro devices. Liquid Rocket Propulsion System: Liquid propellants – classification, Mono and Bi propellants, Cryogenic and storage propellants, ignition delay of hypergolic propellants, physical and chemical characteristics of liquid propellant. Liquid propellant rocket engine – system layout, pump and pressure feed systems, feed system components. Design of combustion chamber, characteristic length, constructional features, and chamber wall stresses. Heat transfer and cooling aspects. Uncooled engines, injectors – various types, injection patterns, injector characteristics, and atomization and drop size distribution, propellant tank design.

Module-4

TURBO JET PROPULSION SYSTEM: Gas turbine cycle analysis –layout of turbo jet engine. Turbo machinery- compressors and turbines, combustor, blade aerodynamics, engine off design performance analysis. Flight Performance: Forces acting on vehicle – Basic relations of motion – multi stage vehicles

Module-5

RAMJET AND INTEGRAL ROCKET RAMJET PROPULSIONSYSTEM: Fuel rich solid propellants, gross thrust, gross thrust coefficient, combustion efficiency of ramjet engine, air intakes and their classification – critical, super critical and sub-critical operation of air intakes, engine intake matching, classification and comparison of IIRR propulsion systems.

Course outcomes:

At the end of the course the student will be able to:

- **CO1:** Understand the aero thermo chemistry of the combustion products.
- **CO2:** Apply concepts to Rocket Engine
- **CO3:** Apply the concepts to ramjet ant jet propulsion system.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook/ Textbooks

1 Mechanics and Dynamics of Propulsion/ Hill and Peterson/John Wiley& Sons

2. Rocket propulsion elements/Sutton/John Wiley & Sons/8th Edition

Reference Books
1. Gas Turbines/Ganesan /TMH
2. Gas Turbines & Propulsive Systems/Khajuria & Dubey/Dhanpat Rai& Sons
3. Rocket propulsion/Bevere
4. Jet propulsion /Nicholas Cumpsty

SIMULATION LABORATORY			
Course Code	20MTPL26	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	0:4:0	SEE Marks	60
Credits	02	Exam Hours	03
Sl.NO	**Experiments**		
1	Build a generic IC engine (petrol /diesel) Model in MATLAB Simulink and draw the performance curves (a) torque v/s speed, (b) power v/s speed, (c) overall efficiency v/s brake power (d) specific fuel consumption v/s brake power and analyse the curves for varied Air:Fuel ratio.		
2	Use a comprehensive model for combustion of fuel at atmospheric pressure and develop a computer programme to estimate the heat released assuming a single step reaction.		
3	Develop computer programme to estimate adiabatic flame temperature of simple fuels such as methane. Use Gibb's Free Energy principle for determining the adiabatic flame temperature.		
4	Using MATLAB Simulink environment SIMDRIVELINE, import a four-wheeler model and run this model at various acceleration and speed and obtain the fuel consumption report. The report must be comprehensive and critical analysis of the result is essential		
5	Develop programmes in C or MATLAB to solve $\frac{\partial u}{\partial t} = \propto \frac{\partial^2 u}{\partial x^2}$ and draw the characteristic curves for various boundary conditions. Use Forward Time Central Space (FTCS) scheme.		
6	Develop programmes in C or MATLAB to solve $\frac{\partial u}{\partial t} = \propto \frac{\partial^2 u}{\partial x^2}$ and draw the characteristic curves for various boundary conditions. Use Dufort-Frankel Model.		
7	Develop programmes in C or MATLAB to solve $\frac{\partial u}{\partial t} = \propto \frac{\partial^2 u}{\partial x^2}$ and draw the characteristic curves for various boundary conditions. Use Lasoonen Model.		
8	Develop programmes in C or MATLAB to solve $\frac{\partial u}{\partial t} = \propto \frac{\partial}{\partial}$ and draw the characteristic curves for various boundary conditions. Use Crank Nicholsen Model.		

TECHNICAL SEMINAR			
Course Code	20MTP27	CIE Marks	100
Number of contact Hours/week (L:P:SDA)	0:0:2	SEE Marks	--
Credits	02	Exam Hours	--

Course objectives:

The objective of the seminar is to inculcate self-learning, face audience confidently, enhance communication skill, involve in group discussion and present and exchange ideas.

Each student, under the guidance of a Faculty, is required to

- Choose, preferably through peer reviewed journals, a recent topic of his/her interest relevant to the Course of Specialization.
- Carryout literature survey, organize the Course topics in a systematic order.
- Prepare the report with own sentences.
- Type the matter to acquaint with the use of Micro-soft equation and drawing tools or any such facilities.
- Present the seminar topic orally and/or through power point slides.
- Answer the queries and involve in debate/discussion.
- Submit two copies of the typed report with a list of references.

The participants shall take part in discussion to foster friendly and stimulating environment in which the students are motivated to reach high standards and become self-confident.

The CIE marks for the seminar shall be awarded (based on the relevance of the topic, presentation skill, participation in the question and answer session and quality of report) by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three faculties from the department with the senior most acting as the Chairperson.

Marks distribution for CIE of the course 20MTP27 seminar:

Seminar Report: 30 marks

Presentation skill:50 marks

Question and Answer:20 marks

*** END OF II SEMESTER***

DESIGN OF HEAT TRANSFER EQUIPMENTS FOR THERMAL POWER PLANT			
Course Code	20MTP31	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

CLASSIFICATION OF HEAT EXCHANGERS: Introduction, Recuperation & regeneration, Tabular heat exchangers, Double pipe, shell & tube heat exchanger, Plate heat Exchangers, Gasketed plate heat exchanger. Spiral plate heat exchanger, Lamella heat exchanger, extended surface heat exchanger, Plate fin and Tabular fin. Basic Design Methods of Heat Exchanger: Introduction, Basic equations in design, Overall heat transfer coefficient, LMTD method for heat exchanger analysis, Parallel flow, Counter flow. Multi pass, cross flow heat exchanger design calculations.

Module-2

DOUBLE PIPE HEAT EXCHANGER: Film coefficient for fluids in annulus, fouling factors, Calorific temperature, Average fluid temperature, The calculation of double pipe exchanger, Double pipe exchangers in series parallel arrangements. Shell & Tube Heat Exchangers: Tube layouts for exchangers, Baffle heat exchangers, Calculation of shell and tube heat exchangers, Shell side film coefficients, Shell side equivalent diameter, The true temperature difference in a 1-2 heat exchanger. Influence of approach temperature on correction factor. Shell side pressure drop, Tube side pressure drop, Analysis of performance of 1-2 heat exchanger and design of shell & tube heat exchangers, Flow arrangements for increased heat recovery, the calculation of 2-4 exchangers.

Module-3

CONDENSATION OF SINGLE VAPOURS: Calculation of horizontal condenser, Vertical condenser, De-Super heater condenser, Vertical condenser-sub-Cooler, Horizontal Condenser-Sub cooler, Vertical reflux type condenser. Condensation of steam.

Module-4

VAPORIZERS, EVAPORATORS AND REBOILERS: Vaporizing processes, Forced circulation vaporizing exchanger, Natural circulation vaporizing exchangers, Calculations of a re-boiler. Extended Surfaces: Longitudinal fins. Weighted fin efficiency curve, Calculation of a Double pipe fin efficiency curve. Calculation of a double pipe finned exchanger, Calculation of a longitudinal fin shell and tube exchanger.

Module-5

DIRECT CONTACT HEAT EXCHANGER: Cooling towers, relation between wet bulb & dew point temperatures, The Lewis number and Classification of cooling towers, Cooling tower internals and the roll of fill, Heat Balance. Heat Transfer by simultaneous diffusion and convection, Analysis of cooling tower requirements, Deign of cooling towers, Determination of the number of diffusion units, Calculation of cooling tower performance.

Course outcomes:

At the end of the course the student will be able to:

- CO1 Understand the physics and the mathematical treatment of typical heat exchangers.
- CO2 Employ LMTD and Effectiveness methods in the design of heat exchangers and analyze the importance of LMTD approach over AMTD approach.
- CO3 Examine the performance of double-pipe counter flow (hair-pin) heat exchangers.
- CO4 Design and analyze the shell and tube heat exchanger.
- CO5 Understand the fundamental, physical and mathematical aspects of boiling and condensation.
- CO6 Classify cooling towers and explain their technical features.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook/ Textbooks
1. James R. Couper; W. Roy Penney, James R. Fair, Stanley M. Walas, Chemical Process Equipment: selection and design, Elsevier Inc., 2nd ed. 2005
2. Process heat transfer- Donald Q.Kern, Tata McGraw Hill Publishing Company Ltd.
3. Heat Exchangers Selection, Rating and Thermal Design- SadikKakac and Hongtan Liu, CRC Press.
4. Process Heat Transfer- Sarit K.Das, Narosa Publishing House Pvt. Ltd.

CONVECTIVE HEAT AND MASS TRANSFER			
Course Code	20MTP321	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

INTRODUCTION TO FORCED, FREE & COMBINED CONVECTION – convective heat transfer coefficient – Application of dimensional analysis to convection – Physical interpretation of dimensionless numbers. Equations of Convective Heat Transfer: Continuity, Navier-Strokes equation & energy equation for steady state flows – similarity – Equations for turbulent convective heat transfer – Boundary layer equations for laminar, turbulent flows – Boundary layer integral equations.

Module-2

EXTERNAL LAMINAR FORCED CONVECTION: Similarity solution for flow over an isothermal plate– integral equation solutions – Numerical solutions – Viscous dissipation effects on flow over a flat plate. External Turbulent Flows: Analogy solutions for boundary layer flows – Integral equation solutions Effects of dissipation on flow over a flat plate. **Internal Laminar Flows:** Fully developed laminar flow in pipe, plane duct & ducts with other cross sectional shapes – Pipe flow & plane duct flow with developing temperature field – Pipe flows & plane duct flow with developing velocity & temperature fields. Internal Turbulent Flows: Analogy solutions for fully developed pipe flow –Thermally developing pipe & plane duct flow.

Module-3

NATURAL CONVECTION: Boussineq approximation – Governing equations – Similarity – Boundary layer equations for free convective laminar flows – Numerical solution of boundary layer equations. Free Convective flows through a vertical channel across a rectangular enclosure – Horizontal enclosure – Turbulent natural convection.

Module-4

COMBINED CONVECTION: Governing parameters & equations – laminar boundary layer flow over an isothermal vertical plate – combined convection over a horizontal plate – correlations for mixed convection – effect of boundary forces on turbulent flows – internal flows - internal mixed convective flows – Fully developed mixed convective flow in a vertical plane channel & in a horizontal duct.

Module-5

CONVECTIVE HEAT TRANSFER THROUGH POROUS MEDIA: Area weighted velocity – Darcy flow model – energy equation – boundary layer solutions for 2-D forced convection – Fully developed duct flow – Natural convection in porous media – filled enclosures – stability of horizontal porous layers. **Convective Mass Transfer**: Basic Definitions and Formulation of a Simplified Theory, Evaluation of The Mass-Transfer Conductance, Examples for application of the Simplified Method.

Course outcomes:

At the end of the course the student will be able to:

- CO1 Understand the fundamental and advanced principles of forced and natural convection heat transfer processes.
- CO2 Formulate and solve convective heat transfer problems
- CO3 Relate the principles of convective heat transfer to estimate the heat dissipation from devices.
- CO4 Estimate the energy requirements for operating a flow system with heat transfer. CO5 Relate to the current challenges in the field of convective heat transfer.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook/ Textbooks
1. Bejan, A., Convection Heat Transfer, John Willey and Sons, New York, 2001.
2. Louis, C. Burmeister, Convective Heat Transfer, John Willey and Sons, New York, 2003.
3. Kays, W.M. and Crawford, M. E., Convective Heat and Mass Transfer, McGraw Hill, New York, 2001

THEORY OF IC ENGINES			
Course Code	20MTP322	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

Introduction to IC Engines: Basic engine components and nomenclature ,Applications of IC Engines **,** Engine characteristics, geometrical properties of reciprocating engines, specific emissions and emission index, relationships between performance parameters, Engine design and performance data. Energy flow through IC engines, Various Auxiliary systems. Environment friendly engines. Fuel –Air and Actual Engines: Modeling of Fuel-Air cycle Effect of operating variables on the performance of Fuel –air Cycles, Detailed analysis of difference between Fuel-Air and Real Cycle, Combustion charts and Gas Tables.

Module-2

Carburetion: Introduction, Factors affecting carburetion, mixture requirements at different load and speed, principles of carburetion, essential parts and functions of a carburetor, compensating devices, Modern Carburetors, Altitude compensation devices, Injection in SI engine. **Injection Systems:** Introduction to Mechanical Injection System, Functional Requirements and classification, Fuel feed pump and Fuel Injector, **Electronic injection systems:** Types, Merits and Demerits, Multi point fuel injection system (MPFI), Electronic control system , Injection timings, Common –Rail Fuel Injection System.

Module-3

Modeling of IC Engines : Governing Equation for open thermodynamic systems, intake and exhaust flow models, Thermodynamic based in cylinder models, Direct-injection CI engine models, Combustion models, Fluid Mechanics based multi-dimensional models.

Module-4

Engine emissions and their control: Air pollution due to IC engines, emission characteristics, Euro norms, engine emissions, Hydro carbon emissions, CO emission, NOx- Photo chemical smog, Particulates, other emissions, Smoke, emission control methods – thermal converters, catalytic converters, particulate traps, Ammonia injection systems, exhaust gas recirculation, ELCD, Crank case blow by control. IC engine Noise characteristics, types, standards and control methods, Air quality emission standards **Measurement:** Noise, Emission, Pressure, crank angle torque, valve timings, temperature and flow measurements.

Module-5

Alternate fuels for IC engines: Vegetable oils, alcohol, LPG, CNG, Hydrogen fuels, Bio gas, Dual fuels, other possible fuels Case studies: The rover K series engine, Chrysler 2.3 liter SI engine, Ford 2, 5 Liter DI Diesel Engine.

Course outcomes:

At the end of the course the student will be able to:

- **CO1:** Distinguish different Fuel-air and actual cycles.
- **CO2:** Demonstrate the different types of injection and carburetor systems
- **CO3:** Formulate the flow and combustion phenomenon for modeling
- **CO4:** Identify the various types of emissions, noise and their control systems
- **CO5:** Recommend the suitable alternative fuel for IC Engine.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook/ Textbooks	
1.	V. Ganesan, “Internal Combustion Engines”, Tata McGraw-Hill Publications, 4th Edition.
2.	John B Heywood, “IC Engines fundamentals”, McGraw- Hill Publications,2011.
3.	C R Fergusan, “Internal Combustion Engines: Applie d Thermo sciences”, John Wiley & Sons.
4.	Richard stone ‘’Introduction to IC Engines’’ Palgrave Publication 3rd edition.
5.	Charles Fayette Taylor ‘’ The Internal-Combustion Engine in Theory and Practice’’ MIT Press 2nd edition.

DESIGN & ANALYSIS OF THERMAL SYSTEMS			
Course Code	20MTP323	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

Thermal Systems: Characteristics- formulation of design problem - Steps in the design process - Modeling of thermal systems – importance - Types of models – Mathematical Modeling, Exponential forms- Method of least squares - Counter flow heat exchanger, Evaporators and Condensers, Effectiveness, NTU, Pressure drop and pumping power.

Module-2

Design of piping and pump systems:- Head loss representation ;Piping networks; Hardy – Cross method Generalized Hardy – Cross analysis; Pump testing methods; Cavitation considerations; Dimensional analysis of pumps; piping system design practice.

Module-3

Unconstrained Optimization Techniques: Univariate, Conjugate Gradient Method and Variable Metric Method. **Constrained Optimization Techniques:** Characteristics of a constrained problem; Direct Method of feasible directions; Indirect Method of interior and exterior penalty functions.

Module-4

Thermo-economic analysis and evaluation: Fundamentals of thermo-economics, Thermo-economic variables for component evaluation; thermo-economic evaluation; additional costing considerations.

Module-5

Thermo-economic optimization: Introduction; optimization of heat exchanger networks; analytical and numerical optimization techniques; design optimization for the co-generation system- a case study; thermo-economic optimization of complex systems.

Course outcomes:

At the end of the course the student will be able to:

- CO1 Formulation of design problems related to thermal Systems.
- CO2 Develop a mathematical model for a given problem.
- CO3 Solve practical problems using suitable optimization technique.
- CO4 Design of piping and pump systems

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook/ Textbooks

1. Thermal Design & Optimization - Bejan, A., et al., John Wiley, 1996.
2. Analysis & Design of Thermal Systems - Hodge, B.K., 2nd edition, Prentice Hall, 1990.
3. Design of Thermal Systems - Boehm, R.F., John Wiley, 1987.
4. Design of Thermal Systems - Stoecker, W.F., McGraw-Hill

PHASE CHANGE PHENOMENA IN FLUIDS			
Course Code	20MTP324	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

Fundamentals: Thermodynamic Equilibrium of Binary and Multi-component mixtures: Fugacity and Fugacity Coefficient of Pure Substance and Mixture, Gibbs Phase Rule. **Binary Mixtures:** Phase Equilibrium Diagrams for Binary Mixtures, Ideal Mixtures, Numerical on phase diagrams of ideal mixtures, Raoult's law of mixture, Zeoptrope and Azoetrope mixture Basic Equations on two phase flow: Mass, Momentum and Energy.

Module-2

Pool Boiling: Boiling regimes, Dimensional Analysis, Nucleate boiling of ordinary fluids, Numerical on nucleate boiling, Film boiling of ordinary fluids, Passive and Active enhancement techniques in heat transfer enhancement.

Module-3

Flow boiling: Boiling regimes in Horizontal and vertical flow, Nucleate boiling in flow, Saturated boiling in flow, Film boiling in flow, Flow boiling for binary mixtures and Augmentation techniques inflow boiling.

Module-4

Flow Patterns and Bubble Dynamics: Flow pattern in Horizontal and vertical tubes: Bubbly flow, plug flow, Stratified flow, Wavy flow, Slug flow and Annular flow. Two phase flow instability: Taylor and Helmholtz instabilities Homogenous and Heterogeneous Nucleation, Rayleigh-Plesset Equation, Bubble Nucleation site density, Bubble size, Bubble departure, Bubble waiting period, Bubble departure and Simple Numerical.

Module-5

Condensation: Film wise condensation: Laminar condensation of vapour, Condensation on tube banks and Numerical. Drop wise Condensation: Condensation of steam-Factors effecting.

Course outcomes:

At the end of the course the student will be able to:

- CO1: Solve for temperature, pressure and enthalpy of Binary mixtures.
- CO2: Solve the basic equations to determine velocity, pressure and temperature of multiphase flow.
- CO3: Analyse pool and flow boiling phenomena to design the heat dissipative cooling equipment.
- CO4: Understand different flow pattern and its instability with bubble behavior
- CO5: Analyse condensation phenomena in the industrial and commercial equipment.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook/ Textbooks

1. Convective boiling and condensation by John G. Collier and John R. Thome, Third edition, Oxford Science Publication.
2. Boiling heat transfer and Multiphase flow by L.S Tong, Second edition, Taylor and Francis Publication.
3. Hand book of Phase Change in Boiling and Condensation by Sathish G. Kandlikar by Taylor and Francis

Reference Books

1. Fundamentals of Multiphase Flows by Christopher E. Brennen, Cambridge University Press 2005.

E Books/Web references

1. https://nptel.ac.in/courses/103105058/
2. https://nptel.ac.in/courses/112107207/

EXPERIMENTAL METHODS IN THERMAL POWER ENGINEERING

Course Code	20MTP331	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

Basics of Measurements: Introduction, General measurement system, Signal flow diagram of measurement system, Inputs and their methods of correction. **Pressure measurement:** Different pressure measurement instruments and their comparison, Transient response of pressure transducers, dead-weight tester, low-pressure measurement.

Module-2

Thermometry: Overview of thermometry, temperature measurement by mechanical, electrical and radiation effects. Pyrometer, Thermocouple compensation, effect of heat transfer. **Thermal and transport property measurement:** Measurement of thermal conductivity, diffusivity, viscosity, humidity, gas composition, pH, heat flux, calorimetry, etc.

Module-3

Flow Measurement: Flow obstruction methods, Magnetic flow meters, Interferometer, LDA, flow measurement by drag effects, pressure probes, other methods. **Nuclear, thermal radiation measurement:** Measurement of reflectivity, transmissivity, emissivity, nuclear radiation, neutron detection, etc. Other measurements: Basics in measurement of torque, strain.

Module-4

Analysis of experimental data: Causes and types of errors in measurement, Propagation of errors, Uncertainty analysis, Regression analysis, Statistical analysis of Experimental data. **Sensing Devices:** Transducers-LVDT, Capacitive, piezoelectric, photoelectric, photovoltaic, Ionization, Photoconductive, Hall-effect transducers, etc.

Module-5

Air-Pollution: Air-Pollution standards, general air-sampling techniques, opacity measurement, sulphur dioxide measurement, particulate sampling technique, combustion products measurement. **Advanced topics:** Issues in measuring thermo physical properties of micro and Nano fluids. **Design of Experiments:** Basic ideas of designing experiments, Experimental design protocols with some examples and DAS.

Course outcomes:

At the end of the course the student will be able to:

- CO1: Understand the concepts of errors in measurements, statistical analysis of data, regression analysis, correlation and estimation of uncertainty.
- CO2: Describe the working principles in the measurement of field and derived quantities.
- CO3: Examine sensing requirements for measurement of thermo-physical properties, radiation properties of surfaces, and vibration.
- CO4: Understand conceptual development of zero, first and second order systems.
- CO5: Interpret International Standards of measurements (ITS-90) and identify internationally accepted measuring standards for measurands.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook/ Textbooks

1. Modern Electronic Instrumentation and Measurement Techniques; Albert D Helfrick and William D Cooper, 2004, PHI.

2.	b. Process Control: Principles and Applications; Surekha Bhanot, Oxford University press, Fourth Impression, 2010.
3.	Instrumentation, Measurement and Analysis; BC Nakra, and KK Chaudhry; 2 ed, 2004, Tata McGraw-Hill
4.	Transducers and Instrumentation; DVS Murthy, 2003, PHI
5.	Instrumentation Devices and Systems; CS Rangan, GR Sarma, and VSV Mani; 2 ed, Tata McGraw-
6.	Measurement Systems Application and Design; Doeblin and Ernest; 5 ed, 2004, Tata McGraw-Hill.
7.	Measurement Systems – Applications & design; Doeblin E.O. 4th ed. Mc. Graw Hill
8.	Principles of Industrial Instrumentation, Patranabis D. TMH – 1997
9.	Mechanical & Industrial Measurements, Jain R.K, Khanna Publishers – 1986
10.	Process Instruments and control Hand book, Considine D.M, 4th ed, Mc.Graw Hill
11.	Instrument Technology – Vol.1m, Jones E.B., Butterworths – 1981
12.	Control Systems Engineering, Nagrath&M.Gopal, Wiley Eastern
13.	Automatic Control Systems, B.C.Kuo, John Wiley, 2009
14.	Modern Control Engineering, Katsuhiko Ogata, Prentice Hall

NON-CONVENTIONAL ENERGY SOURCES

Course Code	20MTP332	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

Introduction: Energy source, India's production and reserves of commercial energy sources, need for nonconventional energy sources, energy alternatives, solar, thermal, photovoltaic. Water power, wind biomass, ocean temperature difference, tidal and waves, geothermal, nuclear (Brief descriptions). **Solar Radiation:** Extra-Terrestrial radiation, spectral distribution of extra-terrestrial radiation, solar constant, solar radiation at the earth's surface, beam, diffuse and global radiation, solar radiation data. **Measurement of Solar Radiation:** Pyrometer, shading ring pyrheliometer, sunshine recorder, schematic diagrams and principle of working.

Module-2

Solar Radiation Geometry: Flux on a plane surface, latitude, declination angle, surface azimuth angle, hour angle, zenith angle, solar altitude angle expression for the angle between the incident beam and the normal to a plane surface (No derivation) local apparent time. Apparent motion of sum, day length, numerical examples. **Solar Thermal systems:** Flat plate collector; Evacuated Tubular Collector; Solar air collector; Solar concentrator; Solar distillation; Solar cooker; Solar refrigeration and air conditioning; Thermal energy storage systems. Solar pond, principle of working. **Solar Photovoltaic systems:** Introduction; Solar cell Fundamentals; Characteristics and classification; Solar cell: Module, panel and Array construction

Module-3

Wind Energy: Properties of wind, availability of wind energy in India, wind velocity and power from wind; major problems associated with wind power, wind machines; Types of wind machines and their characteristics, horizontal and vertical axis wind mills, elementary design principles; coefficient of performance of a wind mill rotor, aerodynamic considerations of wind mill design, numerical examples.

Module-4

Tidal Power: Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, harnessing tidal energy, limitations. **Ocean Thermal Energy Conversion:** Principle of working, Rankine cycle, OTEC power stations in the world, problems associated with OTEC.

Module-5

Geothermal Energy Conversion: Principle of working, types of geothermal station with schematic diagram, geothermal plants in the world, problems associated with geothermal conversion, scope of geothermal energy. **Energy from Bio Mass**: Photosynthesis, photosynthetic oxygen production, energy plantation, bio gas production from organic wastes by anaerobic fermentation, description of bio-gas plants, transportation of biogas, problems involved with bio-gas production, application of bio-gas, application of bio-gas in engines, advantages

Course outcomes:

At the end of the course the student will be able to:

- Describe the need of renewable energy resources, historical and latest developments.
- Describe the use of solar energy and the various components used in the energy production with respect to applications like-heating, cooling, desalination, power generation, drying, cooking etc.
- Appreciate the need of Wind Energy, wave power, tidal power, ocean thermal power and geothermal and the various components used in energy generation.
- Understand the concept of Biomass energy resources and their classification, types of biogas Plants applications

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook/ Textbooks

1. Non-Conventional Energy Sources, G.D Rai, Khanna Publishers, 2003.
2. Non-Convention Energy Resources, B H Khan, McGraw Hill Education (India) Pvt. Ltd. 3rd Edition
3. Solar energy, Subhas P Sukhatme, Tata McGraw Hill, 2nd Edition, 1996.
4. Renewable Energy Sources and Conversion Technology, N K Bansal, Manfred Kleeman & Mechael Meliss, Tata McGraw Hill. 2004.
5. Non-Conventional Energy, Ashok V Desai, Wiley Eastern Ltd, New Delhi, 2003.
6. Renewable Energy Technologies, Ramesh R & Kumar K U, Narosa Publishing House, New Delhi.

GAS DYNAMICS			
Course Code	20MTP333	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

Fundamental equations of steady flow: Definition of Compressible Flow, Flow Regimes, Continuity and momentum equation and energy equation. **Isentropic flow:** Acoustic velocity, Mach number, Mach cone and Mach angle. Flow parameters, stagnation temperature, pressure and density.

Module-2

Variable area flow: Velocity variation with Isentropic flow, Criteria for acceleration and deceleration. Flow through nozzle, Effect of pressure ratio on Nozzle operation. Convergent nozzle and convergent divergent nozzle. Effect of back pressure on nozzle flow. Isothermal flow functions and Flow Generalised one dimensional flows.

Module-3

Flow with normal shock waves: Development of shock wave, Rarefaction wave, Governing equations, Prandtl-Meyer relation, Mach number downstream, Static pressure rise, Density ratio, Temperature ratio, Tables and charts for normal shock.

Module-4

Flow with oblique shock waves: Fundamental relations, Prandtl's equation, Rankine- Hugoniot equation, Variation of flow parameters and Gas tables for oblique shocks. Over-expanded and under expanded flows.

Module-5

Flow in constant area with heat transfer: Stagnation temperature change. Rayleigh line, Pressure ratio and temperature ratio, Entropy considerations and maximum heat transfer. Flow in constant area with friction: Fanno curves, The fanning equation, Friction factor and frictionparameter, Fanno line and Fanno flow equations.

Course outcomes:

At the end of the course the student will be able to:

- CO1: Apply continuity, momentum and energy equations to compressible flows.
- CO2: Analyze isentropic and non-isentropic flows across normal shock waves.
- CO3: Solve compressible flow problems involving heat transfer and friction.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook/ Textbooks

1. Fundamentals of Compressible flow: Yahya, 2nd Edn. 1991; Wieley Eastern.
2. Gas Dynamics, E Radhakrishnan PHI-2006
3. Gas Dynamics, Becker, Academic Press. Inc.

Reference Books

1. Introduction to Gas Dynamics: Rolty, wiley 1998
2. Elements of Gas Dynamics: Liepmann and roshko, Wiley 1994.
3. The dynamics and thermodynamics of compressible fluid flow: Shapiro Ronold press. 1994.
4. Modern Compressible Flow, Anderson John D, McGraw Hill Publication, 1990.

E-Books:

1. Gas Dynamics, E Radhakrishnan PHI (Kindle Edition)
2. Modern compressible flow, Anderson John D, McGraw Hill (Kindle Edition)

THERMAL STORAGE SYSTEM			
Course Code	20MTP334	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

Introduction: Need of Energy Storage, Different modes of Energy Storage, Necessity of thermal storage, Thermal Storage Devices, Areas of Applications of thermal Storage, Heat Transfer Enhancement Methods.

Module-2

Sensible Heat Storage system: Basic concept, Modeling of storage System, Water and rock bed storage- use of TRANSYS, Pressurized water storage in power plant, Packed bed storage, Stratified storage systems, Thermal storage in buildings, Earth storage, Energy storage in aquifers, Heat storage in SHS systems, Aquifers storage. Chemical Energy Storage, Thermo-Chemical, Bio-Chemical, Electro-Chemical, Fossil fuels and synthetic fuels and Hydrogen storage. **08 Hours**

Module-3

Regenerator: Parallel Flow, Counter Flow, Finite conductivity model, Non-linear Model, Transient Performance, Step Change in inlet gas temperature, Step Change in inlet gas Flow rate, Parameterization of Transient Response, Heat Storage exchangers

Module-4

Latent Heat Storage: Storage material modeling of phase change problem, Enthalpy Modeling, Heat Transfer Enhancement Configuration, Parameterization of Rectangular, Cylindrical Geometric Problems, Phase Change Materials(PCMs), Selection Criteria Of PCMs, Stefan Problem, Solar Thermal LHTES Systems, Energy Conservation Through LHTES Systems, LHTES Systems in Refrigeration and Air Conditioning Systems.

Module-5

Applications of Thermal Storage System: Food storage, Waste heat recovery, Solar energy storage, Green house heating, Drying and heating applications, Power Plant Applications, Drying and Heating for Process Industries

Course outcomes:

At the end of the course the student will be able to:

- CO1: Understand the importance of thermal energy storage systems.
- CO2: Study various types of thermal energy storage systems.
- CO3: Study the applications of thermal energy storage systems in various fields.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook/ Textbooks

1.F. W. Schmidt and A.J. Willimot, Thermal Storage and Regeneration, Hemisphere Publishing Corporation, 1981.

2.V J Liunardini, Heat Transfer in Cold Climate, D Van Nostrand Reinhold, NY, 1981.

3.Ibrahim Dincer and Marc A. Rosen, Thermal Energy Storage System and Applications,

PROJECT WORK PHASE – 1			
Course Code	20MTP34	CIE Marks	100
Number of contact Hours/Week	2	SEE Marks	--
Credits	02	Exam Hours	--

Course objectives:

- Support independent learning.
- Guide to select and utilize adequate information from varied resources maintaining ethics.
- Guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- Develop interactive, communication, organisation, time management, and presentation skills.
- Impart flexibility and adaptability.
- Inspire independent and team working.
- Expand intellectual capacity, credibility, judgement, intuition.
- Adhere to punctuality, setting and meeting deadlines.
- Instil responsibilities to oneself and others.
- Train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas.

Project Phase-1 Students in consultation with the guide/s shall carry out literature survey/ visit industries to finalize the topic of the Project. Subsequently, the students shall collect the material required for the selected project, prepare synopsis and narrate the methodology to carry out the project work.

Seminar: Each student, under the guidance of a Faculty, is required to

- Present the seminar on the selected project orally and/or through power point slides.
- Answer the queries and involve in debate/discussion.
- Submit two copies of the typed report with a list of references.

The participants shall take part in discussion to foster friendly and stimulating environment in which the students are motivated to reach high standards and become self-confident.

Course outcomes:

At the end of the course the student will be able to:

- Demonstrate a sound technical knowledge of their selected project topic.
- Undertake problem identification, formulation, and solution.
- Design engineering solutions to complex problems utilising a systems approach.
- Communicate with engineers and the community at large in written an oral forms.
- Demonstrate the knowledge, skills and attitudes of a professional engineer.

Continuous Internal Evaluation

CIE marks for the project report (50 marks), seminar (30 marks) and question and answer (20 marks) shall be awarded (based on the quality of report and presentation skill, participation in the question and answer session by the student) by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three faculty from the department with the senior most acting as the Chairperson.

MINI PROJECT			
Course Code	20MTP35	CIE Marks	40
Number of contact Hours/Week	2	SEE Marks	60
Credits	02	Exam Hours/Batch	03

Course objectives:

- To support independent learning and innovative attitude.
- To guide to select and utilize adequate information from varied resources upholding ethics.
- To guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- To develop interactive, communication, organisation, time management, and presentation skills.
- To impart flexibility and adaptability.
- To inspire independent and team working.
- To expand intellectual capacity, credibility, judgement, intuition.
- To adhere to punctuality, setting and meeting deadlines.
- To instil responsibilities to oneself and others.
- To train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas.

Mini-Project: Each student of the project batch shall involve in carrying out the project work jointly in constant consultation with internal guide, co-guide, and external guide and prepare the project report as per the norms avoiding plagiarism.

Course outcomes:

At the end of the course the student will be able to:

- Present the mini-project and be able to defend it.
- Make links across different areas of knowledge and to generate, develop and evaluate ideas and information so as to apply these skills to the project task.
- Habituated to critical thinking and use problem solving skills.
- Communicate effectively and to present ideas clearly and coherently in both the written and oral forms.
- Work in a team to achieve common goal.
- Learn on their own, reflect on their learning and take appropriate actions to improve it.

CIE procedure for Mini - Project:

The CIE marks awarded for Mini - Project, shall be based on the evaluation of Mini - Project Report, Project Presentation skill and Question and Answer session in the ratio 50:25:25.The marks awarded for Mini - Project report shall be the same for all the batch mates.

Semester End Examination

SEE marks for the mini-project shall be awarded based on the evaluation of Mini-Project Report, Presentation skill and Question and Answer session in the ratio 50:25:25 by the examiners appointed by the University.

INTERNSHIP / PROFESSIONAL PRACTICE			
Course Code	20MTPI36	CIE Marks	40
Number of contact Hours/Week	2	SEE Marks	60
Credits	06	Exam Hours	03

Course objectives:
Internship/Professional practice provide students the opportunity of hands-on experience that include personal training, time and stress management, interactive skills, presentations, budgeting, marketing, liability and risk management, paperwork, equipment ordering, maintenance, responding to emergencies etc. The objective are further,
To put theory into practice.
To expand thinking and broaden the knowledge and skills acquired through course work in the field.
To relate to, interact with, and learn from current professionals in the field.
To gain a greater understanding of the duties and responsibilities of a professional.
To understand and adhere to professional standards in the field.
To gain insight to professional communication including meetings, memos, reading, writing, public speaking, research, client interaction, input of ideas, and confidentiality.
To identify personal strengths and weaknesses.
To develop the initiative and motivation to be a self-starter and work independently. ■

Internship/Professional practice: Students under the guidance of internal guide/s and external guide shall take part in all the activities regularly to acquire as much knowledge as possible without causing any inconvenience at the place of internship.
Seminar: Each student, is required to

- Present the seminar on the internship orally and/or through power point slides.
- Answer the queries and involve in debate/discussion.
- Submit the report duly certified by the external guide.
- The participants shall take part in discussion to foster friendly and stimulating environment in which the students are motivated to reach high standards and become self-confident. ■

Course outcomes:
At the end of the course the student will be able to:

- Gain practical experience within industry in which the internship is done.
- Acquire knowledge of the industry in which the internship is done.
- Apply knowledge and skills learned to classroom work.
- Develop a greater understanding about career options while more clearly defining personal career goals.
- Experience the activities and functions of professionals.
- Develop and refine oral and written communication skills.
- Identify areas for future knowledge and skill development.
- Expand intellectual capacity, credibility, judgment, intuition.
- Acquire the knowledge of administration, marketing, finance and economics. ■

Continuous Internal Evaluation
CIE marks for the Internship/Professional practice report (20 marks), seminar (10 marks) and question and answer session (10 marks) shall be awarded (based on the quality of report and presentation skill, participation in the question and answer session by the student) by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three faculty from the department with the senior most acting as the Chairperson. ■

Semester End Examination
SEE marks for the internship report (30 marks), seminar (20 marks) and question and answer session (10 marks) shall be awarded (based on the quality of report and presentation skill, participation in the question and answer session) by the examiners appointed by the University. ■

PROJECT WORK PHASE -2			
Course Code	20MTP41	CIE Marks	40
Number of contact Hours/Week	4	SEE Marks	60
Credits	20	Exam Hours	03

Course objectives:

- To support independent learning.
- To guide to select and utilize adequate information from varied resources maintaining ethics.
- To guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- To develop interactive, communication, organisation, time management, and presentation skills.
- To impart flexibility and adaptability.
- To inspire independent and team working.
- To expand intellectual capacity, credibility, judgement, intuition.
- To adhere to punctuality, setting and meeting deadlines.
- To instil responsibilities to oneself and others.
- To train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas. ■

Project Work Phase - II: Each student of the project batch shall involve in carrying out the project work jointly in constant consultation with internal guide, co-guide, and external guide and prepare the project report as per the norms avoiding plagiarism. ■

Course outcomes:
At the end of the course the student will be able to:

- Present the project and be able to defend it.
- Make links across different areas of knowledge and to generate, develop and evaluate ideas and information so as to apply these skills to the project task.
- Habituated to critical thinking and use problem solving skills
- Communicate effectively and to present ideas clearly and coherently in both the written and oral forms.
- Work in a team to achieve common goal.
- Learn on their own, reflect on their learning and take appropriate actions to improve it. ■

Continuous Internal Evaluation:
Project Report: 20 marks. The basis for awarding the marks shall be the involvement of the student in the project and in the preparation of project report. To be awarded by the internal guide in consultation with external guide if any.
Project Presentation: 10 marks.
The Project Presentation marks of the Project Work Phase -II shall be awarded by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three faculty from the department with the senior most acting as the Chairperson.
Question and Answer: 10 marks.
The student shall be evaluated based on the ability in the Question and Answer session for 10 marks.
Semester End Examination
SEE marks for the project report (30 marks), seminar (20 marks) and question and answer session (10 marks) shall be awarded (based on the quality of report and presentation skill, participation in the question and answer session) by the examiners appointed by the University. ■