VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examination – 2018-19
M.Tech in Thermal Engineering/Thermal Power Engineering (MTP)
Outcome Based Education(OBE) and Choice Based Credit System (CBCS)

I SEMESTER

Sl. No	Course	Course Code	Title	Teaching Hours /Week		Examination				Credits
				Theory	Field work/ Assignment	Duration in hours	CIE Marks	Marks	Total Marks	
1	PCC	18MTP11	Mathematics	04	--	03	40	60	100	4
2	PCC	18MTP12	Finite Element Method	04	--	03	40	60	100	4
3	PCC	18MTP13	Advanced Fluid Mechanics	04	--	03	40	60	100	4
4	PCC	18MTP14	Thermodynamics &Combustion Engineering	04	--	03	40	60	100	4
5	PEC	18MTP15	Energy Conservation and Management	04	--	03	40	60	100	4
6	PCC	18MTPL16	Thermal Engineering measurement - Lab 1	-	04	03	40	60	100	2
7	PCC	18RMI17	Research Methodology and IPR	02	--	03	40	60	100	2
			TOTAL	**22**	**04**	**21**	**280**	**420**	**700**	**24**

Note: PCC: Professional core, PEC: Professional Elective.

Internship: All the students have to undergo mandatory internship of 6 weeks during the vacation of I and II semesters and /or II and III semesters. A University examination shall be conducted during III semester and the prescribed credit shall be counted forthe same semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared as failed and have to complete during the subsequent University examination after satisfying the internship requirements.

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II SEMESTER

Sl. No	Course	Course Code	Title	Teaching Hours /Week		Examination				Credits
				Theory	Practical/ Field work/ Assignment	Duration in hours	CIE Marks	SEE Marks	Total Marks	
1	PCC	18MTP21	Advanced Heat Transfer	04	--	03	40	60	100	4
2	PCC	18MTP22	Steam &Gas Turbines	04	--	03	40	60	100	4
3	PCC	18MTP23	Refrigeration and Air Conditioning	04	--	03	40	60	100	4
4	PEC	18MTP24X	Professional elective 1	04	--	03	40	60	100	4
5	PEC	18MTP25X	Professional elective 2	04	--	03	40	60	100	4
6	PCC	18MTPL26	Simulation Laboratory Projects on Thermal Engineering - Lab 2	--	04	03	40	60	100	2
7	PCC	18MTP27	Technical Seminar	--	02	-	100	-	100	2
TOTAL				**20**	**06**	**18**	**340**	**360**	**700**	**24**

Note: PCC: Professional core, PEC: Professional Elective, OEC: Open Elective, Aud: Audit Course

Professional Elective 1		**Professional Elective 2**	
Course Code under 18MTP24X	**Course title**	**Course Code under 18MTP25X**	**Course title**
18MTP241	Advanced Power Plant Cycles	18MTP251	Theory of 1C Engines
18MTP242	Thermal Power Station – 1	18MTP252	Modeling and Simulation of Thermal Systems
18MTP243	Alternate Fuels for 1C Engines	18MTP253	Computational Methods in Heat Transfer &Fluid Flow

Note:

1. Technical Seminar:CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide, if any, and a senior faculty of the department. Participation in the seminar by all postgraduate students of the same and other semesters of the programme shall be mandatory.

The CIE marks awarded for Technical Seminar, shall be based on the evaluation of Seminar Report, Presentation skill and Question and Answer session in the ratio 50:25:25.

2. Internship: All the students shall have to undergo mandatory internship of 6 weeks during the vacation of I and II semesters and /or II and III semesters. A University examination shall be conducted during III semester and the prescribed credit shall be counted in the same semester.Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared as failed and have to complete during the subsequent University examination after satisfying the internship requirements.

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III SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week		Examination				Credits
				Theory	work / Assignmen	ion in hours	Marks	s	Total Marks	
1	PCC	18MTP31	Design of heat Transfer Equipments for thermal power plant	04	--	03	40	60	100	4
2	PEC	18MTP32X	Professional elective-3	04	--	03	40	60	100	4
3	PEC	18MTP33X	Professional elective- 4	04	--	03	40	60	100	4
4	Proj	18MTP34	Evaluation of Project phase -1	--	02	--	100	--	100	2
5	INT	18MTPI35	Internship	(Completed during the intervening vacation of I and II semesters and /or II and III semesters.)		03	40	60	100	6
TOTAL				12	02	12	**260**	**240**	**500**	**20**

Note: PCC: Professional core, PEC: Professional Elective.

Professional elective 3		**Professional elective 4**	
Course Code under 18XXX32X	**Course title**	**Course Code under 18XXX33X**	**Course title**
18MTP321	Convective Heat and Mass Transfer	18MTP331	Experimental Methods in Thermal Power Engineering
18MTP322	Engine Flow & Combustion	18MTP332	Biomass Conversion and Technologies
18MTP323	Design & Analysis of Thermal Systems	18MTP333	CAD for thermal engineering

Note:

1. Project Phase-1: Students in consultation with the guide/co-guide if any, shall pursue literature survey and complete the preliminary requirements of selected Project work. Each student shall prepare relevant introductory project document, and present a seminar.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide if any, and a senior faculty of the department. The CIE marks awarded for project work phase -1, shall be based on the evaluation of Project Report, Project Presentation skill and Question and Answer session in the ratio 50:25:25.

SEE (University examination) shall be as per the University norms.

2. Internship: Those, who have not pursued /completed the internship shall be declared as failed and have to complete during subsequent University examinations after satisfying the internship requirements.

Internship SEE (University examination) shall be as per the University norms.

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IV SEMESTER

Sl. No	Course	Course Code	Title	Teaching Hours /Week		Examination				Credits
				Theory	Field work/ Assignment	Duration in hours	CIE Marks	SEE Marks Viva voce	Total Marks	
1	Proj	18MTP41	Project work phase -2	--	04	03	40	60	100	20
			TOTAL	--	**04**	**03**	**40**	**60**	**100**	**20**

Note: PC: Proj: Project.

Note:

1. Project Phase-2:

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide, if any, and a Senior faculty of the department. The CIE marks awarded for project work phase -2, shall be based on the evaluation of Project Report subjected to plagiarism check, Project Presentation skill and Question and Answer session in the ratio 50:25:25.

SEE shall be at the end of IV semester. Project work evaluation and Viva-Voce examination (SEE), after satisfying the plagiarism check, shall be as per the University norms.

GRADUATE ATTRIBUTES

The Graduate Attributes are the knowledge skills and attitudes, which the students have at the time of graduation. These attributes are generic and are common to all engineering programs. These Graduate Attributes are identified by National Board of Accreditation.

1. Scholarship of Knowledge: Acquire in-depth knowledge of various manufacturing processes on a wider and global perspective, with an ability to discriminate, evaluate, analyze and synthesize existing and new knowledge, and integration of the same for enhancement of knowledge.

2. Critical Thinking: Analyze complex engineering problems critically, apply independent judgment for synthesizing information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.

3. Problem Solving: Think laterally and originally, conceptualize and solve manufacturing engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, societal and environmental factors in the core areas of expertise.

4. Research Skill: Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyze and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.

5. Usage of modern tools: Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities with an understanding of the limitations.

6. Collaborative and Multidisciplinary work: Possess knowledge and understanding of group dynamics, recognize opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.

7. Project Management and Finance: Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economic and financial factors.

8. Communication: Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.

9. Life-long Learning: Recognize the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.

10. Ethical Practices and Social Responsibility: Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.

11. Independent and Reflective Learning: Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.

PROGRAM EDUCATIONAL OBJECTIVES:

Program Educational Objectives (PEOs) are broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve. They must be consistent with the mission of the Institution and Department. Department faculty members must continuously work with stakeholders (local employers, industry and RD advisors, and the alumni) to review the PEOs and update them periodically. The number of PEOs should be manageable and small in number, say 4+1, and should be achievable by the program.

PEO1.	Apply concepts of thermal engineering including thermodynamics, heat transfer and fluid mechanics to design and develop energy efficient equipment.
PEO2.	Model and design thermal systems using computational and optimization techniques.
PEO3.	Adopt methods of energy conservation for sustainable development.
PEO4.	Communicate effectively and support constructively towards team work.
PEO5.	Pursue lifelong learning for career and professional growth with ethical concern for society and environment.

Mapping of program educational objectives with graduate attributes

PEO	GA1	GA2	GA3	GA4	GA5	GA6	GA7	GA8	GA9	GA10	GA11
PEO1	3	2	3	3	1	2	2	-	1	1	1
PEO2	2	2	3	2	3	2	1	-	1	1	1
PEO3	2	2	3	2	3	2	1	-	1	1	1
PEO4	1	1	-	1	-	1	2	3	3	2	2

PROGRAM OUTCOMES:

Program Outcomes, as per NBA, are narrower statements that describe what the students are expected to know and be able to do upon the graduation. These relate to the knowledge, skills and behavior the students acquire through the program. The Program Outcomes (PO) are specific to the program and should be consistent with the Graduate Attributes and facilitate the attainment of PEOs.

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

PO1	Understand advanced concepts of thermal engineering systems.
PO2	Apply principles of thermal engineering to improve the performance of energy conversion devices.
PO3	Perform tests on thermal energy conversion devices as per standards and interpret results.
PO4	Apply finite element, CFD and optimization techniques to model, analyze and simulate thermal systems.
PO5	Analyze thermal systems and their components for optimal performance.
PO6	Identify sources of harmful engine emissions to develop pollution abatement techniques.
PO7	Design and analyze the performance of gas turbines and propulsion devices.
PO8	Apply concepts of thermal engineering to execute research projects.
PO9	Apply principles of measurements for performance evaluation of thermal systems.
PO10	Identify viable renewable energy sources and develop appropriate ways to harness them.
PO11	Translate competencies to support team effort.
PO12	Engage in lifelong learning for career and professional growth with ethical concern for society and environment.

Mapping of program outcomes with program educational objectives

PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PEO1	3	3	3	2	3	2	-	3	3	1	2	2
PEO2	3	2	1	3	3	-	1	3	-	1	1	2
PEO3	3	3	3	3	2	3	1	2	2	3	-	3
PEO4	2	2	3	-	-	-	-	2	2	-	3	2
PEO5	2	1	2	-	-	1	-	1	-	2	3	3

ISEMESTERM.TECH. THERMAL ENGINEERING.
FINITE ELEMENT METHOD

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Finite Element Method	18MTP12	04	4-0-0	60	40	3Hrs
Common to MTP,MTH						

Course Objectives

1. Introduce the various aspects of FEM as applied to thermal engineering problems.
2. Apply the fundamental concepts of mathematical methods to solve Heat Conduction, Transient and Phase Change ,Convective Heat Transfer problems.

1. **Introduction:** Historical Perspective of FEM and applicability to Thermal Engineering problems.
   Conduction Heat Transfer and Formulation: Modelling 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.

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, Subparametric, superparametric and Isoparametric elements. Formulation of conductive, convective matrices and nodal heat rate vectors. Analysis procedure for 2 D conduction with convection

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.

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
   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.

5. **Structural problems:** Finite element formulation for structural problems, 1 dimensional stress analysis problems with bar, beam, truss and frame elements, FE formulation in plane stress, plane strain and axi-symmetric problems. Introduction to plate bending and shell elements.

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 element characteristic 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.

Text Books:

1. Reddy J.N.,Gartling. D.K., The Finite Element Method in Heat Transfer and Fluid dynamics, CRC Press, 2007.
2. Lewis R.W., et al..The Finite Element method in Heat Transfer Analysis, John Wiley & Sons
3. SingiresuS.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.

ISEMESTERM.TECH. THERMAL ENGINEERING.
ADVANCED FLUID MECHANICS

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Advanced Fluid Mechanics	18MTP13	04	4-0-0	60	40	3Hrs
Common to MTP,MTH						

Course Objectives

To understand the kinematics of fluids, their governing equations, Mechanics of laminar and turbulent flow, NS Equations and Experimental Techniques.

1. Introduction: Properties of Fluids ,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. **10 Hours**

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 equationmodel for fully turbulent flowsand other turbulence models; turbulent flow through pipes; losses in bends, valves etc; analysis of pipenetwork - Hard cross method. **10 Hours**

3.Exact and Approximate solutions of N-S Equations: Introduction; Parallel flow past a sphere; Oseen's approximation; hydrodynamic theoryof 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.**10 Hours**

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

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.**10 Hours**

5.Experimental Techniques: Introduction; improved modeling through experiments; design of fluid flow experiments; error sources duringmeasurement; pressure transducers; hot wire anemometer; laser - Doppler velocity meter; methods of measuring turbulence fluctuations - flow visualization techniques; wind tunnel; analysis of experimental uncertainty - types of error, estimation of uncertainty.**10 Hours**

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

CO1 Explain the basic concepts fluid flow and their governing equations

CO2 Understand the concepts in the analysis of fluid flow problems in laminar and Turbulent flows

CO3 Formulate and solve one dimensional incompressible and compressible fluid flow problems

CO4 Distinguish normal and oblique shocks and their governing equations.

CO5 Identify relevant instruments and methods for flow measurements

Text Books:

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.

ISEMESTERM.TECH. THERMAL ENGINEERING.
THERMODYNAMICS &COMBUSTION ENGINEERING

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Thermodynamics &Combustion Engineering	18MTP14	04	4-0-0	60	40	3Hrs
Common to MTP,MTH						

Course Objective:

- Predict the availability and irreversibility associated with the thermodynamic processes.
- Analyze the properties of ideal and real gas mixtures,
- Study the tehavior of pure substances and to understand the basic concepts of combustion, flame propagation and types of flames.

1. Introduction: Overview of the course-Thermo chemistry of combustion-Concept of Adiabatic Flame Temperature-Numerical Problems
Chemical Kinetics: Differences between equilibrium and rate controlled reactions- Global versus Elementary Reactions. Elementary reaction rates, bimolecular reactions and collision theory, other elementary reactions, Relation between rate coefficients and equilibrium constants, Steady-state Approximation. The mechanism for Uni-molecular reactions, Chain and Chain-Branching reactions.
10 Hours
2. Introduction to species Mass Transfer: Rudiments of Mass Transfer, Mass Transfer Rate Laws, and Species Conservation. The Stefan Problem, Liquid-vapor interface boundary conditions, Droplet evaporation, Numerical.
Simplified Conservation Equations for Reacting Flows: Overview-Overall Mass Conservation(Continuity)Species mass Conservation(Species Continuity) Momentum Conservation,1-D and 2-D forms, Energy Conservation-General 1-D Form, Shvab- Zeldovich Forms, Definition of Mixture Fraction. 10 Hours

3. Laminar Premixed Flames**:** Physical Description, Definition, Principal characteristics, Typical Laboratory Flames. Simplified Analysis, Assumptions, Conservation Laws, Solution, Factors Influencing flame velocity and Thickness: temperature, pressure, Equivalence ratio, fuel type, Flame speed Correlations for Selected fuels, Quenching, Flammability, and Ignition Flame lift-off (Blow-off) and flash back, Concept of Flame stretch-Karlovitz number, Flame Stabilization.10 Hours
4. Introduction to Turbulent Flames: Theories of flame propagation, thermal, diffusion and comprehensive theories turbulent length and time scales, Weak turbulent flames. Wrinkled Reaction Sheets, Distributed Reaction zones. 8 Hours
5.Pollutant Emissions: Effects of emissions, Quantification of Emissions, Emission Indices, Corrected concentrations, Various Specific emission measures-Emissions from PremixedCombustion: Oxides **of** Nitrogen, Carbon Monoxide, Unburned Hydrocarbons, Catalytic After-treatment, Particulate Matter.Emissions from non-Premixed Combustion: Oxides of Nitrogen, Unburned Hydrocarbons and Carbon Monoxide, Particulate Matter and Oxides of Sulfur, Numerical Problems12 Hours

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

1. Stephen, R. Turns., Combustion, McGraw Hill, 2005.
2. Mishra, D.P., Introduction to Combustion, Prentice Hall,2009

CO1 Understand the concepts of combustion phenomena in energy conversion devices.

CO2 Apply the knowledge of adiabatic flame temperature in the design of combustion devices.

CO3 Identify the phenomenon of flame stabilization in laminar and turbulent flames.

CO4 Analyze the pollution formation mechanisms in combustion of solid, liquid and gaseous fuels.

READING

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Energy Conservation and Management	18MTP15	04	4-0-0	60	40	3Hrs
Common to MTP,MTH						

3. Sharma, S. P., Fuels and Combustion, Tata McGraw Hill, New Delhi, 2001.
4. Heywood Internal Combustion Engine Fundamentals, McGraw Hill Co.1988
5. JürgWarnatz, Ulrich Maas and Robert W. Dibble Combustion: Physical and Chemical Fundamentals, Modelling and Simulation, Experiments, Pollutant Formation, 1999.

ISEMESTERM.TECH. THERMAL ENGINEERING.
ENERGY CONSERVATION AND MANAGEMENT

Course Objective:

- To get exposure to energy management of thermal and electrical systems and to Understand the various conservation techniques.

1. Energy Conservation: Introduction - Indian Energy Conservation Act - List of EnergyIntensive Industries - Rules for Efficient Energy Conservation - Identification of EnergyConservation opportunities - Technologies for Energy Conservation – EnergyConservation Schemes and Measures - Energy flow net works - Critical assessment ofenergy use - Optimizing Energy Inputs and Energy Balance - Pinch Technology.**10 Hours**

2. Energy Efficiency Improvement: Steam Generation - Distribution and Utilization –Furnaces - Fans and Blowers - Compressors Pumps - Pinch Technology - Fluidized bedCombustion - Heat Exchanger Net works - Case Studies - Analysis andrecommendation.**10 Hours**

3. Energy Audit: Definition and Concepts, Types of Energy Audits – Basic Energy Concepts –Energy audit questionnaire, Data Gathering – Analytical Techniques. Energy Consultant: Needof Energy Consultant – Consultant Selection Criteria, Economic Analysis: Scope, Characterization of an Investment Project – Types of Depreciation –Time Value of money – budget considerations, Risk Analysis.**10 Hours**

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.**08 Hours**

5. Economics of Generation and Distribution: Generation: Definitions - Connected load, Maximum demand - Demand factor –Diversity factor – Significance - Power Factor – Causes and disadvantages of low powerfactor – 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 – GreenLabeling – Star Rating.**12 Hours**

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

CO1 Understand the various conservation techniques.
CO2 Explain various Energy Efficiency Improvement technique
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

READING:

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.

ISEMESTERM.TECH. THERMAL ENGINEERING.

THERMAL ENGINEERING MEASUREMENT - LAB 1

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Thermal Engineering measurement - Lab 1	18MTPL16	02	0-0-3	60	40	3Hrs
Common to MTP,MTH						

Course Objective

- This course will provide a basic understanding of flow measurements using various types of flow measuring devices, calibration and losses associated with these devices.

- Energy conversion principles, analysis and understanding of hydraulic turbines, Pumps and I C Engines will be discussed. Application of these concepts for these machines will be demonstrated. Performance analysis will be carried out using characteristic curves.
- Exhaust emissions of I C Engines will be measured and compared with the standards

Course Content:

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 upto 2 litres 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 rotameter to measure the flow rate of water with a maximum flowrate of 0.25 litres per second. Obtain the calibration curve for the scale fixed on the rotameter 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.

COURSE OUTCOMES: At the end of the course, the student will be able to:

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

- Conduct experiments on hydraulic turbines and pumps to draw characteristics.
- Test basic performance parameters of hydraulic turbines and pumps and execute the knowledge in real life situations.
- Identify exhaust emission, factors affecting them and report the remedies.
- Determine the energy flow pattern through the hydraulic machines and I C Engine
- Exhibit his competency towards preventive maintenance of IC engines.

Reading:

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:, pub.: 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.

IISEMESTERM.TECH.THERMAL ENGINEERING.

Advanced Heat Transfer

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Advanced Heat Transfer	18MTP21	04	4-0-0	60	40	3Hrs
Common to MTP,MTH						

Course Objective:

- To develop the ability to use the heat transfer concepts for various applications like finned systems, turbulence flows, high speed flows.
- To analyze the thermal analysis and sizing of heat exchangers and to learn the heat transfer coefficient for compact heat exchanges.

- To have an understanding of the numerical technique to handle heat transfer problems

Course Content:

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.**12 Hours**

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

8Hours

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.**10Hours**

4.Natural 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**12 Hours**

5.Heat exchangers: Basic concepts**,**types of heat exchangers, Analysis of heat exchangers, Counter-Flow Heat Exchangers, Multipass 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 phaseflow**10 Hours**

Reference Books:

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

Course Outcome:after undergoing this course students are able to

- Summarize both the physics and the mathematical treatment of the advanced topics pertaining to the modes of heat transfer.
- Use principles of heat transfer to develop mathematical models for uniform and non-uniform fins.

- ❖ Employ mathematical functions and heat conduction charts in tackling two- dimensional and three-dimensional heat conduction problems.
- ❖ Identify free and forced convection problems involving complex geometries with proper boundary conditions.
- ❖ Use the concepts of radiation heat transfer for enclosure analysis.

IISEMESTERM.TECH. THERMAL ENGINEERING.

STEAM AND GAS TURBINES

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Steam and Gas Turbines	18MTP22	04	4-0-0	60	40	3Hrs
Common to MTP,MTH						

Course Objective:

- ❖ To understand the working principle, operations and analysis of nozzles, diffusers, steam and gas turbines.

Course Content:

1.Nozzles and diffusers: Introduction types of nozzles, types of Diffusers, Equation of Continuity Sonic Velocity and Mach Numbers, TheSteady 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. **10 Hours**

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. **10 Hours**

3.Flow of Steam Through Impulse-Reaction Turbine Blades: Velocity diagram, degree of reaction, impulse- reaction turbine with similarblade 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 impulseturbine, 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.**10 Hours**

4.Axial Flow and Centrifugal Compressors : Elementary theory, compressibility effects, factors affecting stage pressure ratio, blockage incompressor 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 pointperformance 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.
10 Hours

5.Axial and Radial Flow Gas Turbines and Prediction of performance: Elementary theory of axial flow turbine, vortex theory, choice ofblade 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 windage losses, losses due to shrouding, Discfriction ,radiation and conduction,mechanical losses ,leakage through the end seals.

10 Hours

Reference Books:

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

Course Outcome:after undergoing this course students are able to

- Summarize the working principles of Gas and steam turbines nozzle and diffusers.
- Use the principles of thermodynamics to determine the performance of steam and gas turbines.
- Distinguish and demonstrate the working principle and performance of impulse and reaction turbines
- Explain the concepts of axial flow and centrifugal compressors
- Differentiate axial flow and radial flow gas turbines for their analysis.
- Identify the various losses associated with the turbines.

IISEMESTERM.TECH. THERMAL ENGINEERING.

REFRIGERATION AND AIR CONDITIONING

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Refrigeration and Air Conditioning	18MTP23	04	4-0-0	60	40	3Hrs
Common to MTP,MTH						

Course Objective:

- Study the basic definition, ASHRAE Nomenclature for refrigerating systems

- Understand the working principles and applications of different types of refrigeration systems
- Study the working of air conditioning systems and their applications
- Identify the performance parameters and their relations of an air conditioning system

1. Refrigeration cycles **– analysis: Development of Vapor Compression Refrigeration Cycle from Reverse Carnot Cycle- conditions for high COP-deviations from ideal vapor compression cycle ,Multipressure 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 Behaviour with fluctuating load.** 10 Hours

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.** 10 Hours

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, Bypass Factor. Applications with specified ventilation air quantity- Use of ERSHF, Application with low latent heat loads and high latent heat loads.**12 Hours**

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 Air flow. **08 Hours**

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.**10 Hours**

COURSE OUTCOMES: At the end of the course, the student will be able to:

CO1	Understand physical and mathematical aspects of refrigeration and air- conditioning systems.
CO2	Employ the theoretical and mathematical principles to simple, complex vapour compression and vapour absorption refrigeration systems.
CO3	Understand conventional and alternate refrigerants and their impact on environment.
CO4	Design air-conditioning systems.

READING:

1. Roy J. Dossat, Principles of Refrigeration, Wiley Limited 2002
2. Arora C.P., Refrigeration and Air-conditioning, 3rd edition,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.
5. Principles and Refrigeration- Goshnay W.B., Cambridge, University Press, 1985.
6. Solid state electronic controls for HVACR' -Langley, Billy C., 'Prentice-Hall 1986
7. Refrigeration and Air Conditioning- Arora C.P., Tata McGraw Hill Pub. Company
8. Handbook of Air Conditioning Systems design- Carrier Air Conditioning Co., McGraw Hill,
9. Refrigeration and Air Conditioning (3/e) - Langley Billy C., Engie wood Cliffs (N.J) PHI.
10. Fundamentals and equipment- 4 volumes-ASHRAE Inc. 2005.
11. Air Conditioning Engineering-Jones, Edward Amold pub. 2001.

IISEMESTERM.TECH. THERMAL ENGINEERING.

ADVANCED POWER PLANT CYCLES

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Advanced Power plant Cycles	18MTP241	04	4-0-0	60	40	3Hrs
Common to MTP,MTH						

Course Objective:

- To provide a knowledge about the analysis of various cycles used for power generation, Combustion, kinetics involved in combustion.
- To impart knowledge about feed water circulation, working of FWH.

Course Content:

1.Analysis of Steam cycles: Rankine cycle, Carnot cycle, mean temperature of heat addition, effect of variation of steam condition on thermalefficiency of steam power plant, reheating of steam, regeneration, regenerative feed water heating, feed water heaters, carnotization of Rankine cycle, optimum degree of regeneration, Super critical pressure cycle, steam power plant appraisal, Deaerator, typical layout of steam power plant, efficiencies in a steam 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 powercycle, Binary vapor cycles, coupled cycles , combined cycle plants, gas turbine- steam turbine power plant, MHD-steam power plant, Thermionic- Steam power plant. **10 Hours**

2.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 firingsystem, 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 furnce /combustion chamber.

10Hours

3.Steam Generators: Basic type of steam generators, fire tube boilers, water tube boilers. Economizers, superheaters, reheaters, steam generatorcontrol, 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 watersystem, cooling towers, calculations, Numerical Problems. **10 Hours**

4.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. **10 Hours**

5.Hydro Electric Power Plant: Introduction, advantages and disadvantages of water power, optimization of hydro – thermal mix, hydrologicalcycles, storage and pondage

Power plant Economics: Definitions, Principles, Location of power plant, cost analysis selection of type of generation, selection of power plant equipments **10 Hours**

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

Course Outcome:after undergoing this course students are able to

- Distinguish the various power plant cycle and their working principles.
- Explain combustion phenomenon of different type of fuels and energy associated.
- Demonstrate the working principles of different components of power plant.
- Explain the concepts of power generation by nuclear power plant.
- Differentiate axial flow and radial flow gas turbines for their analysis.
- Identify the design parameters and economics of power plant.

IISEMESTERM.TECH. THERMAL ENGINEERING.

Elective-1

Thermal Power Station-I

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Thermal Power Station-I	18MTP242	04	4-0-0	60	40	3Hrs
Common to MTP,MTH						

Course Objective:

- To study the working ,operation and maintenance of a various steam generator components .
- To understand the arrangements of different flow systems their operation and maintenance and their effects on environment.
- To have the knowledge of working expenses ,current scenario and trends in power generation .

Course Content:

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**12 Hours**

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. **8 Hours**

3.Feed Water system: Impurities in water and its effects, feed and boiler water corrosion, quality of feed water, boiler drum water treatment andsteam 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. **12 Hours**

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.**10 Hours**

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**10 Hours**

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

Course Outcome:after undergoing this course students are able to

- Describe the working, operation and maintenance of a various steam generator components.
- Identify the arrangements of different flow systems their operation and maintenance and their effects on environment.
- Estimate the working expenses, current scenario and trends in power generation.
- Asses the performance and suitability .

IISEMESTERM.TECH. THERMAL ENGINEERING.

Elective-1

Alternate Fuels for IC Engines

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Alternate Fuels for IC Engines	18MTP243	04	4-0-0	60	40	3Hrs
Common to MTP,MTH						

Course Objective:

- To have a knowledge about conventional fuels, their current usage and limitations.
- To understand and identify the suitable alternative fuels and their relevance ,importance and limitation

Course Content:

1.Conventional Fuels: Introduction, Current fuel scenario and consumption, per capita consumption Indian scenario, Structure of petroleum, Refining process, Products of refining process, Fuels for spark ignition, Knock rating of SI enginefuels, Octane number requirement, Diesel fuels.

Properties of petroleum products: Specific gravity, Density, Molecular weight, Vapour pressure, Viscosity, Flash point, Fire point, Cloudpoint, Pour point, Freezing point, Smoke point & Char value, Aniline point, Octane Number, Performance Number, Cetane Number, Emulsification, Oxidation Stability, Acid Value/Number, Distillation Range, and Sulphur content.**10Hours**

2.Alternative fuels for I.C. engines: Need for alternative fuels such as Ethanol, Methanol, LPG, CNG, Hydrogen, Biogas and Producer gas andtheir methods of manufacturing.

Single Fuel Engines: Properties of alternative fuels, Use of alternative fuels in SI engines, Engine modifications required, Performance andemission characteristics of alternative fuels in SI mode of operation v/s gasoline operation. **10Hours**

3.Dual fuel Engine: Need and advantages, The working principle, Combustion in dual fuel engines, Factors affecting combustion in dual fuelengine, Use of alcohols, LPG, CNG, Hydrogen, Biogas and Producer gas in CI engines in dual fuel mode. Engine modifications required. Performance and emission characteristics of alternative fuels (mentioned above) in Dual Fuel mode of operation v/s Diesel operation.**10 Hours**

4. Bio-diesels: What are bio-diesels Need of bio-diesels, Properties of bio-diesels v/s petro-diesel, Performance and emission characteristics ofbio-diesels v/s Petro diesel operation.

Availability: Suitability & Future prospects of these gaseous fuels in Indian context.**10 Hours** **10Hou**

5.Environmental pollution: with conventional and alternate fuels, Pollution control methods and packages.Euro norms , Engineemissions, Emission control methods, EPA. Air quality emission standards 10**Hours**

Reference Books:

1. **A Course in Internal Combustion Engines -** R.P Sharma & M.L. Mathur, DanpatRai& Sons.
2. **Elements of Fuels, Furnaces & Refractories -** O.P. Gupta, Khanna Publishers.
3. **Internal Combustion Engines -**Domkundwar V.M., I Edition, DhanpatRai& Sons.
4. **Internal Combustion Engines Fundamentals -** John B. Heywood, McGraw Hill International Edition.
5. **Present and Future Automotive Fuels -** Osamu Hirao& Richard Pefley, Wiley Interscience Publications.
6. **Internal Combustion Engines -** V. Ganesan, Tata McGraw-Hill Publications.

Course Outcome:after undergoing this course students are able to

- Explain about the availability and usage of conventional fuels for IC engines.
- Identify possible alternative fuels for IC engines.
- Demonstrate the use of alternative fuels for different types of engines
- Assess the environmental impact standards and procedures of using alternate fuels.

IISEMESTERM.TECH. THERMAL ENGINEERING.

THEORY OF I C ENGINES

Elective-2

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Theory of I C Engines	18MTP251	04	4-0-0	60	40	3Hrs
Common to MTP,MTH						

Course Objective:

- To understand the working cycle, Engine design and operating conditions, combustion phenomena, Engine emission and control,
- use of alternate fuels in IC engines.

Course Content:

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.Envirnoment 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. **10 Hours**

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 .**10 Hours**

3.Modelling 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**10 Hours**

4.Engine emissions and their control: Air pollution due to IC engines, emission characteristics ,Euro norms, engine emissions, Hydro carbon emissions,COemission,NOx- Photo chemical smog ,Particulates,otheremissions,Smoke,emission control methods – therm alconverters, 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 **10 Hours**

5.Alternate fuels for I.C engines: Vegetable oils, alcohol’s, L.P.G, C.N.G, Hydrogen fuels,Bio gas ,Dual fuels,other possible fuels

Case studies : The rover K series engine,Chrysler 2.3 litre SI engine, Ford 2,5 Litre DI Diesel Engine**10 Hours**

Reference Books:

1. V. Ganesan, “Internal Combustion Engines”, Tata McG raw-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 Enginein Theory and Practice’’ MIT Press 2nd edition.

Course Outcome:after undergoing this course students are able to

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

IISEMESTERM.TECH. THERMAL ENGINEERING.

MODELING AND SIMULATION OF THERMAL SYSTEMS

Elective-2

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Modeling and Simulation of Thermal Systems	18MTP252	04	4-0-0	60	40	3Hrs
Common to MTP,MTH						

Course Objective:

- To have the knowledge about basic principles of thermodynamics, heat transfer and fluid mechanics for modeling and simulation techniques
- To have the understanding of modeling and simulation.
- To study the design and performance of thermal system using modeling and simulation

Course Content:

1.Principle Of Computer Modeling And Simulation: Monte Carlo simulation, Nature of computer modeling and simulation, limitations ofsimulation, areas of application.

System And Environment: components of a system —discrete and continuous sy stems. Models of a system-a variety of modeling approaches.

2.Random Number Generation: technique for generating random numbers —mid squar e method- The mid product method- constantmultiplier technique-additive congruential method — linear congruential method —tests for random number s —the kolmogorov-simrnov test-the Chi-square test.

Random Variable Generation: inversion transform technique- exponential distribution- uniform distribution-weibul distribution empiricalcontinuous distribution- generating approximate normal variates —Erlang distribution. **12Hours**

3.Empirical Discrete Distribution: Discrete uniform distribution—poissondistribution- geometricdistribution- acceptance-rejectiontechnique for poission distribution-gamma distribution.

Design And Evaluation Of Simulation Experiments: variance reduction techniques-antithetic variables-variables-verification and validationof simulation models.**10Hours**

4.Discrete Event Simulation: concepts in discrete-event simulation, manual simulation using event scheduling, single channel queue, twoserver queue simulation of inventory problem.
9 Hours
5. Introduction to GPSS: Programming for discrete event systems in GPSS, case studies.
9Hours
Reference Books:

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.

Course Outcome:after undergoing this course students are able to

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

IISEMESTERM.TECH. THERMAL ENGINEERING.

COMPUTATIONAL METHODS IN HEAT TRANSFER & FLUID FLOW

Elective-2

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
COMPUTATIONAL METHODS IN HEAT TRANSFER & FLUID FLOW	18MTP253	04	4-0-0	60	40	3Hrs
Common to MTP,MTH						

Course Objective:

- To understand the numerical techniques to solve ODE and PDE relevant to heat and fluid flow systems.
- To learn the possible numerical tools to formulate flow situations.
- To identify the temperature and energy distribution over the computational domain.

Course Content:

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.

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.

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.

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.

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 tetra hedral 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.
8Hours

Reference Books:

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 Dynamics**Versteeg, H.K. and Malalasekara, W., , Pearson Education, 2010.

Course Outcome:

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

IISEMESTERM.TECH. THERMAL ENGINEERING.

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Simulation Laboratory Projects on Thermal Engineering - Lab 2	18MTPL26	02	0-0-2	60	40	3Hrs
Common to MTP,MTH,MCS						

Note:

- These are independent laboratory exercises
- A student may be given one or two problems stated herein
- Student must submit a comprehensive report on the problem solved and give aPresentation on the same for Internal Evaluation
- Any one of the exercises done from the following list has to be asked in the Examination for evaluation.
- Computer programme can be developed in ‘C’ or MATLAB.
- MATLAB Simulink can be used wherever applicable.

Course Content:

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 $\frac{\partial u}{\partial t} = \propto \frac{\partial^2 u}{\partial x^2}$ and draw the characteristic curves for various boundary conditions. Use Crank Nicholsen Model.

IISEMESTERM.TECH. THERMAL ENGINEERING.

TECHNICAL SEMINAR

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Technical Seminar	18MTP27	02	2-0-0	-	100	3Hrs

COURSE OUTCOMES

CO1	Identify and compare technical and practical issues related to the area of course specialization.
CO2	Outline annotated bibliography of research demonstrating scholarly skills.
CO3	Prepare a well organized report employing elements of technical writing and critical thinking
CO4	Demonstrate the ability to describe, interpret and analyze technical issues and develop competence in presenting.

III SEMESTER M.TECH. THERMAL ENGINEERING

DESIGN OF HEAT TRANSFER EQUIPMENTS FOR THERMAL POWER PLANT

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	

Design of heat Transfer Equipments for thermal power plant	18MTP31	04	4-0-0	60	40	3Hrs
Common to MTP,MTH						

Course Objective:

- Study the modes of heat transfer involved in heat exchanger design .
- Study the basic principles of heat exchanger analysis and thermal design.
- Understand the principles of direct contact heat exchanger

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. Multipass, cross flow heat exchanger design calculations:**08Hours**

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.
12Hours
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.**10Hours**

4. **VAPORIZERS, EVAPORATORS AND REBOILERS**: Vaporizing processes, Forced circulation vaporizing exchanger, Natural circulation vaporizing exchangers, Calculations of a reboiler. 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.**10Hours**
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.**10Hours**

Course Outcome

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.

READING

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. 1.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.
5. Standards of the Tubular Exchange Manufacturers Association, TMEA, New York.
6. Heat exchanger design- Press and N. Ozisik.
7. Heat Exchangers- Kakac, S., A.E. Bergles and F. Mayinger (Eds.) Hemisphere, 1981.
8. Compact Heat exchangers- Kays, W.M., and A.L. London, McGraw Hill.

IIISEMESTERM.TECH. THERMAL ENGINEERING.

CONVECTIVE HEAT AND MASS TRANSFER
(Elective-3)

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Convective Heat and Mass Transfer	186MTP321	04	4-0-0	60	40	3Hrs
Common to MTP,MTH						

Course Objective

- Use empirical correlations for fully-developed laminar, turbulent internal flows and external boundary layer convective flow problems.
- Study the basic principles of mixed convective flow and their heat transfer analysis .
- Understand the principles of convective heat transfer through porous media related engineering problems.

1. **INTRODUCTION TO FORCED, FREE & COMBINED CONVECTION** – convective heat transfer coefficient – Applicationof dimensional analysis to convection – Physical interpretation of dimensionless numbers.Equations of Convective Heat Transfer: Continuity, Navier-Strokes equation & energy equation forsteady state flows – similarity – Equations for turbulent convective heat transfer – Boundary layerequations for laminar, turbulent flows – Boundary layer integral equations.**10Hours**

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 flatplate.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 crosssectionalshapes – Pipe flow & plane duct flow with developing temperature field – Pipe flows & planeduct flow with developing velocity & temperature fields.Internal Turbulent Flows: Analogy solutions for fully developed pipe flow –Thermally developingpipe & plane duct flow.**12Hours**

3. **NATURAL CONVECTION**: Boussineq approximation – Governing equations – Similarity – Boundarylayer equations for free convective laminar flows – Numerical solution of boundary layer equations.Free Convective flows through a vertical channel across a rectangular enclosure – Horizontalenclosure – Turbulent natural convection.**08Hours**

4. **COMBINED CONVECTION**: Governing parameters & equations – laminar boundary layer flow overan isothermal vertical plate – combined convection over a horizontal plate – correlations for mixedconvection – effect of boundary forces on turbulent flows – internal flows - internal mixed convectiveflows – Fully developed mixed convective flow in a vertical plane channel & in a horizontal duct.**10Hours**

5. **CONVECTIVE HEAT TRANSFER THROUGH POROUS MEDIA**: Area weighted velocity – Darcy flowmodel – energy equation – boundary layer solutions for 2-D forced convection – Fully developed ductflow – 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.

10Hours

Course Outcome

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.

READING:

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.

IIISEMESTERM.TECH.THERMAL ENGINEERING.

ENGINE FLOW AND COMBUSTION
(Elective-3)

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Engine Flow and Combustion	18MTP322	04	4-0-0	60	40	3Hrs
Common to MTP,MTH						

Course Objective

- Study the Inlet& exhaust processes of I C Engine.
- Understand the combustion phenomenon of I C Engines pollutant formation
- Study the combustion models nd emission norms.

1.Gas exchange process: Inlet & exhaust processes in four stroke cycle, volumetric efficiency, flow through valves, residual gas fraction,exhaust gas flow rate and temperature variation, super charging, turbo charging.Intake jet flow, mean velocity turbulence characteristics, swirl, squish, pre chamber engine flows, creviceflow and blow by, flows generated by piston cylinder wall interaction.**10Hours**

2.Combustion in IC Engines: Combustion in SI engines: Ignition, flame velocity, Normal andabnormal combustion, knocking, pre-ignition, effect of engine variables on knocking, featuresand design consideration of combustion chambers, concept of lean burn engines, Combustion inCI engines: Air motion: Swirl and squish, spray formation and vaporization, Stages ofcombustion, physical and chemical delay, diesel knock, effect of engine variables on dieselknock, combustion chambers: design features, Combustion characteristics of Biodiesel andBiodiesel blends, Low NOx diesel combustion: homogeneous charge compression ignitionengine (HCCI- combustion), pHCCI, and EGR techniques**10Hours**

3.Combustion Models: Fuel spray: Factors influencing fuel spray atomization, Spray equationmodels, penetration and dispersion of fuel, fuel line hydraulics, fuel pumps and injectors, Zerodimensional modeling, quasi dimensional modeling, combustion systems: efficiency and itsapplications, Single zone models, multi zone models, Premixed and diffusive models, Heattransfer coefficients, and specific heat relations, Weibes function analysis, two zone models, heattransfer in IC engines, heat transfer correlations, data logging and acquisition, cylinder-pressuremeasurement and Gross and net release rate calculations.
10Hours
4.Engine Emissions and Air-Pollution: Emissions and its Formation: Gaseous emissions: CO,CO_2, HC, NOx (NO & NO_2), SOx (SO_2 & SO_3); particulate matter (PM), Sources of emissionformation; Emissions formation mechanisms of PM and NOx; volatile organic compounds(VOCs), poly aromatic hydrocarbons (PAH), soluble organic fraction (SOF); Mechanism of airpollution: Ozone depletion, Greenhouse effect, Photochemical smog, acid rain, Effect of airpollutionon health and environment, Emission norms (passenger and commercial vehicles):National and International emission standards: BS-III and BS-IV & Euro III, IV, and V**10Hours**

5.Emission Control Technologies and Emission Measurements: PM reduction technologies:Diesel oxidation catalysts (DOCs), Diesel particulate filters (DPFs), closed crankcase ventilation(CCV); NOx reduction technologies: Exhaust gas recirculation (EGR), Selective catalyticreduction (SCR), Lean NOx catalysts (LNCs), Lean NOx traps (LNTs), NOx adsorber catalysts,Exhaust gas recirculation (EGR), Diesel exhaust after treatment: diesel oxidation catalyst (DOC), diesel particulate filter (DPF), Soot suppression by fuel additives, relationship: soot, combustionchamber and swirl ratio, catalytic convertors: constructional features and types: 2-way and 3-way catalytic convertors. Measurement of gaseous emissions using thermal, chemical, magneticand optical gas analyzers: infrared gas analyzer, chemiluminescent analyzer, gaschromatography, smoke (soot) measurement, application of microprocessor in emission control.Trends of emission reduction**10Hours**

Course Outcome

- Understand the Engine inlet and exhaust flow systems
- Explain the phynomenon of I C Engine combustion and their pollutant formation
- Distinguish different combustion models of I C Engines.
- Explain the emission norms and their controlling measures.

READING

1. Combustion Modeling in Reciprocating Engines, by James N Mattavi and Charles A Amann, Plenum press, 1980
2. Thermodynamic Analysis of Combustion Engines, by Ashley S Campbell, John Wiley and Sons, 1980
3. Internal Combustion Engines and Air Pollution, by Edward .F Obert, Intext Education Publishers, 1980
4. Automotive Emission Control , Crouse William, Gregg division, McGraw-Hill,
5. Internal Combustion Engine Fundamentals, John B. Heywood, Tata McGraw-Hill,1998
6. Internal combustion engine modeling, by J I Ramos, Hemisphere Publishing Corporation, 1989
7. Experimental Methods for Engineers by Holman J. P, McGraw-Hill,1988
8. Computer Simulation of Spark Ignition Engine Processes, by Ganesan V., University press, 1995

IIISEMESTERM.TECH.THERMAL ENGINEERING.

DESIGN & ANALYSIS OF THERMAL SYSTEMS

(Elective-3)

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Design & Analysis of Thermal Systems	18MTP323	04	4-0-0	60	40	3Hrs
Common to MTP,MTH						

Course Objective

- Have an exposure to different Design Methodologies and simulation processes.

1. Thermal Systems: Characteristics- formulation of design problem - Steps in the designprocess - Modeling of thermal systems – importance - Types of models – MathematicalModeling, Exponential forms- Method of least squares - Counter flow heat exchanger, Evaporators and Condensers, Effectiveness, NTU, Pressure drop and pumping power**10Hours**

2.Design of piping and pump systems:- Head loss representation ;Piping networks ; Hardy – Cross method Generalized Hardy – Crossanalysis ; Pump testing methods ; Cavitation considerations ; Dimensional analysis of pumps ; piping system design practice.**10Hours**

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.**10Hours**

4.Thermo-economic analysis and evaluation:- Fundamentals of thermo-economics, Thermo-economic variables for component evaluation ;thermo-economic evaluation ; additional costing considerations.
10Hours

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.**10Hours**

Course outcome

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

CO5 Developthermo-economic analysis and evaluation,optimization for variety of industrial problems.

READING

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

IIISEMESTERM.TECH.THERMAL ENGINEERING.

EXPERIMENTAL METHODS IN THERMAL POWER ENGINEERING

(Elective-4)

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Experimental Methods in Thermal Power Engineering	18MTP331	04	4-0-0	60	40	3Hrs
Common to MTP,MTH						

Course Objective

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.

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.

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.

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.

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.

READING

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-Hill
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

IIISEMESTERM.TECH.THERMAL ENGINEERING.

BIOMASS CONVERSION AND TECHNOLOGIES

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Biomass Conversion and Technologies	18MTP332	04	4-0-0	60	40	3Hrs
Common to MTP,MTH						

OBJECTIVES:

- To have an exposure on the types of biomass, its surplus availability and characteristics.
- Analyze the technologies available for conversion of biomass to energy in terms of its technical competence and economic implications.

1. Origin of Biomass: Resources - Classification and characteristics - Techniques for biomass assessment - Application of remote sensing in forest assessment – Biomass estimation.
2. Thermochemical Conversion: Different processes - Direct combustion – Incineration – Pyrolysis - Gasification and liquefaction - Economics of thermochemical conversion.

3. Biological Conversion: Biodegradation and biodegradability of substrate – Biochemistry and process parameters of biomethanation - Biogas digester types - Digester design and biogas utilization.
   Biomethanation Process - Economics of biogas plant with their environmental and social impacts - Bioconversion of substrates into alcohol - Methanol & ethanol Production - Organic acids – Solvents - Amino acids - Antibiotics etc

4. Chemical Conversion: Hydrolysis & hydrogenation - Solvent extraction of hydrocarbons Solvolysis of wood - Biocrude and biodiesel - Chemicals from biomass

5. Power Generation: Utilisation of gasifier for electricity generation - Operation of spark ignition and compression ignition engine with wood gas – Methanol - ethanol & biogas - Biomass integrated gasification/combined cycles systems - Sustainable cofiring of biomass with coal - Biomass productivity - Energy plantation and power programme.

References Books:

1. Biotechnology and Alternative Technologies for Utilization of Biomass, Chakraverthy A
2. Biogas Systems: Principles and Applications, Mital K.M
3. Biomass Energy Systems, Venkata Ramana P and Srinivas S.N
4. Gasification Technologies, A Primer for Engineers and Scientists Rezaiyan. J and N. P.
5. Cheremisinoff.
6. Biomass Gasification – Principles and Technology, Tom B Reed, Noyce Data Corporation, 1981.
7. Bio Energy Technology Thermodynamics and costs, David Boyles, Ellis Hoknood Chichester,1984.
8. Khandelwal KC, Mahdi SS, Biogas Technology – A Practical Handbook, Tata McGraw Hill, 1986.
9. Bio Energy for Rural Energisation, Mahaeswari, R.C. Concepts Publication,1997
10. Best Practises Manual for Biomass Briquetting, I R E D A, 1997.
11. The briquetting of Agricultural wastes for fuel, Eriksson S. and M. Prior, FAO Energy and Environment paper, 1990.
12. Thermochemical Characterization of Biomass, Iyer PVR , M N E S

Course Outcome: After undergoing this course students are able to

- Understand the various biomass energy conversion technologies and its relevance towards solving the present energy crisis.
- Explain Origin of Biomass,resources and classification and characteristics of biomass
- Summarize power generation techniques of biomass with their environmental and social impacts
- Demonstrate the chemical conversion process

IIISEMESTERM.TECH.THERMAL ENGINEERING.

CAD FOR THERMAL ENGINEERING

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
CAD for thermal engineering	18MTP333	04	4-0-0	60	40	3Hrs
Common to MTP,MTH						

Course Objective:

- **To** develop mathematical models to represent curves.
- Model engineering components using solid modeling techniques.
- Design and analysis of engineering components.

1. Introduction to CAD: Introduction to CAD, CAD input devices, CAD output devices, CAD Software, Display Visualization Aids, and Requirements of Modeling. 2D Translation, 2D Scaling, 2D Reflection, 2D Rotation, Homogeneous representation of transformation, Concatenation of transformations.

2. 3D Transformations of geometry and Projections: 3D Translation, 3D Scaling, 3D Reflection, 3D Rotation, Homogeneous representation of transformation, Concatenation of transformations, Perspective, Axonometric projections, Orthographic and Oblique projections.

3. Design of Curves : Analytic Curves, PC curve, Ferguson, Composite Ferguson, curve Trimming and Blending, Bezier segments, de Castellan’s algorithm, Bernstein polynomials, Bezier-

subdivision, Degree elevation, Composite Bezier, Splines, Polynomial Splines, B-spline basis functions, Properties of basic functions, Knot Vector generation, NURBS.

4. Design of Surfaces : Differential geometry, Parametric representation, Curves on surface, Classification of points, Curvatures, Developable surfaces, Surfaces of revolution, Intersection of surfaces, Surface modeling, 16-point form, Coons patch, B-spline surfaces.

5. Design of Solids: Solid entities, Boolean operations, B-rep of Solid Modeling, CSG approach of solid modeling, advanced modeling methods. Data Exchange Formats and CAD Applications: Data exchange formats, Finite element analysis, reverse engineering, modeling with point cloud data, Rapid prototyping.

READING:

1. Ibrahim Zeid and Sivasubramanian, R., CAD/CAM Theory and Practice, Tata McGraw Hill Publications, New Delhi, 2009.

2. David F. Rogers, J. A. Adams, Mathematical Elements for Computer Graphics, TMH, 2008.

Course Outcome

CO1	Understand geometric transformation techniques in CAD.
CO2	Develop mathematical models to represent curves.
CO3	Design surface models for engineering applications.
CO4	Model engineering components using solid modeling techniques.
CO5	Design and analysis of engineering components.

IIISEMESTERM.TECH.THERMAL ENGINEERING.

EVALUATION OF MINI PROJECT PHASE -1

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Evaluation of Project phase -1	18MTP34	02	0-2-0	60	40	3Hrs

1. Project Phase-1: Shall be carried out duringIII Semester. Students in consultation with the guide/co-guide if any, shall pursue literature survey and complete the preliminary requirements of selected Project work. Each student shall prepare relevant introductory project document, present a seminar and appear for an oral examination for both CIE and SEE. CIE shall be by a committee comprising of HoD as Chairman, Guide and Senior faculty of the department and SEE (University examination) shall be as per the University norms.

COURSE OUTCOMES

CO1	Identify a topic in advanced areas of thermal engineering
CO2	Review literature to identify gaps and define objectives & scope of the work
CO3	Employ the ideas from literature and develop research methodology
CO4	Develop a model, experimental set-up and / or computational techniques necessary to meet the objectives.

IIISEMESTER M.TECH. THERMAL ENGINEERING.

INTERNSHIP

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Internship	18MTP135	06	-	60	40	3Hrs

(Completed during the intervening vacations of I and II semesters and /or II and III semesters.)

Internship: Those, who have not pursued /completed the internship shall be declared as failed and have to complete during subsequent University examinations after satisfy the internship requirements. InternshipSEE (University examination) is as per the University norms.

COURSE OUTCOME:

CO1	Develop integrative thinking and learn about organizational realities
CO2	Find and frame problems, collecting, synthesizing and distilling large volumes of ambiguous data, engaging in generative and lateral thinking, constantly experiment and learn.
CO3	Develop industry ready skill set
CO4	Demonstrate the ability to describe, interpret and analyze technical issues pertaining to industry products

IVSEMESTERM.TECH. THERMAL ENGINEERING.

PROJECT WORK PHASE -2

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Project work phase -2	18MTP41	20	0-4-0	60	40	3Hrs

Project Phase-2: During IV semester**.**

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide, if any and a Senior faculty of the department. The CIE marks awarded for project work phase -2, shall be based on the evaluation of Project Report subjected to plagiarism check, Project Presentation skill and Question and Answer session in the ratio 50:25:25.

SEE shall be at the end of IV semester. Project work evaluation and Viva-Voce examination (SEE), after satisfying the plagiarism check, shall be as per the University norms.

COURSE OUTCOMES:

CO1	Identify methods and materials to carry out experiments/develop code
CO2	Reorganize the procedures with a concern for society, environment and ethics
CO3	Analyze and discuss the results to draw valid conclusions
CO4	Prepare a report as per the recommended format and defend the work.
CO5	Explore the possibility of publishing papers in peer reviewed journals/conference proceedings.

WASTE TO ENERGY

Open elective

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Waste to energy	18MTP256	04	4-0-0	60	40	3Hrs
Common to MTP,MTH						

COURSE OUTCOMES

CO1	Understand the types and composition of various types of wastes
CO2	Identify various types and composition of various types of wastes
CO3	Explain energy from waste-thermo chemical conversion
CO4	Summarize the principles of energy from waste
CO5	Compare environmental and health impact case studies

1. **Introduction to Waste & Waste processing**: Definitions, sources, types and composition of various types of wastes; Characterisation of Municipal Solid Waste (MSW) , Industrial waste and Biomedical Waste (BMW), waste collection and transportation; waste processing-size reduction, separation; waste management hierarchy, waste minimization and recycling of MSW; Life Cycle Analysis (LCA), Material Recovery Facilities (MRF), recycling processes of solid waste;

2. **Waste Treatment and disposal**: Aerobic composting, incineration, different type of incineration; medical and pharmaceutical waste incinerations- land fill classification, types, methods and sitting consideration, layout and preliminary design of landfills: composition, characteristics, generation, movement and control of landfill leachate and gases, environmental monitoring system for land fill gases

3. **Energy from waste-thermo chemical conversion**: Sources of energy generation, incineration, pyrolysis, gasification of waste using gasifiers, briquetting, utilization and advantages of briquetting,- environmental and health impacts of incineration; strategies for reducing environmental impacts.

4. **Energy from waste-** Bio-chemical Conversion: Anaerobic digestion of sewage and municipal wastes, direct combustion of MSW-refuse derived solid fuel, industrial waste, agro residues, anaerobic digestionbiogas production, land fill gas generation and utilization, present status of technologies for conversion of waste into energy, design of waste to energy plants for cities, small townships and villages.

5. **Environmental and health impacts-case studies**: Environmental and health impacts of waste to energy conversion, case studies of commercial waste to energy plants, waste to energy- potentials and constraints in India, eco-technological alternatives for waste to energy conversions – Rules related to the handling, treatment and disposal of MSW and BMW in India.

References:

1. Municipal Solid Waste to Energy Conversion Processes: Economic, Technical, and Renewable Comparisons, by
2. Gary C. Young, ISBN:9780470539675, Publisher: John Wiley & Sons, Publication Date: June 2010.
3. Recovering Energy from Waste Various Aspects Editors: Velma I. Grover and Vaneeta Grover, ISBN 978-1- 57808-200-1; 2002
4. Shah, Kanti L., Basics of Solid & Hazardous Waste Management Technology, Prentice Hall, 2000.
5. Rich, Gerald et.al., Hazardous Waste Management Technology, Podvan Publishers, 1987.
6. Waste-to-Energy by Marc J. Rogoff, DEC-1987, Elsiever, ISBN-13: 978-0-8155-1132-8, ISBN-10: 0-8155- 1132-9.
7. Parker, Colin, & Roberts, Energy from Waste - An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985.
8. Manoj Datta, Waste Disposal in Engineered Landfills, Narosa Publishing House, 1997.
9. Bhide A. D., Sundaresan B. B., Solid Waste Management in Developing Countries, INSDOC, New Delhi, 1983.
10. Robert Green, From Waste to Energy, Cherry Lake Pub. ISBN: 1602795096, 2009.
11. G. Evans, Biowaste and Biological Waste Treatment, 2005
12. Biogas from waste and renewable resources, by Dieter D. And Angelika S. Wiley-Vch Publication 2010.