Semester- II

Advanced Heat Transfer			
Course Code	MMTP201	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:2:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 10-12 Lab slots	Total Marks	100
Credits	04	Exam Hours	3

Course Learning objectives:

- To present a comprehensive and rigorous treatment of conductive, Fins, and unsteady state heat transfer by emphasizing the engineering and engineering arguments.
- To develop the ability to use the analysis of convection heat transfer for various applications like boundary layer, laminar and turbulent boundary layer flows.
- To understand the natural and forced convection heat transfer process applied to industrial applications.
- To develop an intuitive understanding of radiative heat transfer and different types of heat exchangers to learn real engineering problems.

MODULE-1

Introduction and one-dimensional heat transfer: The 3-D differential equation of heat conduction in cartesian, cylindrical and spherical coordinates, Steady state heat conduction in one dimensional, With heat generation, Critical thickness of insulation, two-dimensional steady state heat conduction, Problems.

Conduction Unsteady State: Lumped heat capacity, Transient heat flow, Extended Surfaces- Fins of uniform cross section and non-uniform cross sections, Thermal resistance networks and applications. problems.

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

MODULE-2

Analysis of Convection Heat Transfer: Boundary layer fundamentals evaluation of convection heat transfer coefficient, Hydrodynamic and thermal boundary layer, Dimensional analysis for forced and free convection, Blasius solution for laminar boundary layer flow over a flat plate, Approximate integral boundary layer analysis, Integral energy equation, Turbulent boundary layer, Analogy between momentum and heat transfer in turbulent flow over a flat surface, Reynolds Analogy for Turbulent Flow Over Plane Surfaces, Mixed boundary layer.

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

MODULE-3

Natural and Forced Convection Heat Transfer: Introduction, Similarity Parameters for Natural Convection, Approximate analysis of natural convection on vertical plate, Empirical Correlation for Various Shapes, Rotating Cylinders, Disks, and Spheres, Natural convection from finned surfaces. **Forced convection:** Turbulent tube flow, Empirical Correlations in laminar and turbulent flow over various shapes, Flow across bluff objects, packed beds and bank of tubes, combined natural and forced convection.

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

MODULE-4
Thermal radiation: Basic concepts and laws of thermal radiation, the shape factor, Heat Exchange Between Non-Black Bodies, Enclosures with Black Surfaces and Grey surfaces, radiation shields and Radiation Effect on temperature measurements. Radiation properties of participating Medium, Emissivity and absorptivity of Gases and Gas Mixtures, problems. **Boiling and Condensation**: Boiling heat transfer, Pool Boiling Correlations, Laminar Film Condensation on a Vertical Plate, Turbulent Film Condensation, Condensation in Horizontal Tubes, Problems.

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

MODULE 5
Heat exchangers: Basic concepts, types of heat exchangers, Analysis of heat exchangers, LMTD and NTU of Parallel flow and Counter-Flow Heat Exchangers, Multi pass and Crossflow Heat Exchangers, Use of a Correction Factor, Selection of Heat Exchangers such as Heat Transfer Rate, Cost, Pumping Power, Size and Weight, Type, Materials, Other Considerations, Compact Heat Exchangers, Heat Exchangers for multi-phase flow.

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

PRACTICAL COMPONENT OF IPCC *(May cover all / major modules)*

Sl.NO	Experiments
1	To find out the overall thermal conductance and plot the temperature distribution in case of a composite wall

2	To calculate the overall heat transfer coefficient for parallel flow and counter current flow heat exchanger.
3	To find out the Heat Transfer Coefficient of vertical cylinder in natural convection
4	To find out the temp. Distribution along the length of a Pin Fin under free convection and forced convection
5	Determination of Thermal Conductivity of Insulating Material and Thermal Conductivity of Liquid
6	To find the heat transfer co-efficient for Drop-wise condensation and Film-wise condensation process.
7	Determination of Heat Transfer Coefficient in a free Convection on a vertical tube.
8	Determination of Heat Transfer Coefficient in a Forced Convention Flow through a Pipe.
9	Determination of Critical Heat Flux.
10	Determination of Emissivity of a Surface.
11	Determination of Stefan Boltzman Constant.
12	Performance Test on Vapour Compression Refrigeration.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIE for the theory component of IPCC

1. Two Tests each of **25 Marks**
2. Two assignments each of **25 Marks/One Skill Development Activity of 50 marks**
3. Total Marks of two tests and two assignments/one Skill Development Activity added will be CIE for 60 marks, marks scored will be proportionally scaled down to **30 marks**.

CIE for the practical component of IPCC

- On completion of every experiment/program in the laboratory, the students shall be evaluated and marks shall be awarded on the same day. The **15 marks** are for conducting the experiment and preparation of the laboratory record, the other **05 marks shall be for the test** conducted at the end of the semester.

- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for **10 marks**. Marks of all experiments' write-ups are added and scaled down to **15 marks**.

- The laboratory test at the end /after completion of all the experiments shall be conducted for **50 marks** and scaled down to **05 marks.**

Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **20 marks**.

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SEE for IPCC

Theory SEE will be conducted by the University as per the scheduled timetable, with common question papers for the course (duration 03 hours)

1. The question paper will be set for 100 marks and marks scored will be scaled down proportionately to 50 marks.
2. The question paper will have ten questions. Each question is set for 20 marks.
3. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
4. The students have to answer 5 full questions, selecting one full question from each module.

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper shall include questions from the practical component).

- The minimum marks to be secured in CIE to appear for SEE shall be the 15 (50% of maximum marks-30) in the theory component and 10 (50% of maximum marks -20) in the practical component. The laboratory component of the IPCC shall be for CIE only. However, in SEE, the questions from the laboratory component shall be included**.** The maximum of 04/05 questions to be set from the practical component of IPCC, the total marks of all questions should not be more than the 20 marks.

- SEE will be conducted for 100 marks and students shall secure 40% of the maximum marks to qualify in the SEE. Marks secured will be scaled down to 50. (Student has to secure an aggregate of 50% of maximum marks of the course (CIE+SEE)

Suggested Learning Resources:

Books

1. Heat Transfer- A practical Approach: Yunus A Cengel: McGraw-Hill Publications 2nd edition
2. Heat Transfer – A Basic Approach - Ozisik M.N., McGraw-Hill Publications, 1st edition.
3. Heat Transfer - Holmon J.P., McGraw-Hill Publications, 6th Edition.
4. Principles of Heat Transfer - Frank Kreith, Thomson Publications, 7th Edition.
5. Fundamentals of Heat and Mass Transfer: Theodore L. Bergman, Adrienne S. Lavine, Frank P. Incropera, David P. Dewitt seventh edition John Wiley & Sons, Inc

6. Heat and mass Transfer: Er. R.K. Rajput, S. Chand & Company Ltd., 5th Edition.
Web links and Video Lectures (e-Resources): • https://archive.nptel.ac.in/courses/103/105/103105052/ • https://archive.nptel.ac.in/courses/103/105/103105140/ • https://archive.nptel.ac.in/courses/112/107/112107256/ • https://archive.nptel.ac.in/courses/112/103/112103297/ • https://archive.nptel.ac.in/courses/103/101/103101137/ • https://archive.nptel.ac.in/courses/112/108/112108246/
Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

Sl. No.	Description	Blooms Level
CO1	Ability to understand modes of heat transfer with energy equation and develop models for physical problems and analyze steady state, fins, and transient heat conduction problems of real-life thermal systems	
CO2	Identify and explain the concepts of Boundary layers using Laminar and turbulent conditions.	
CO3	Understand and recognize the free and forced convection problems in real time applications.	
CO4	Apply different methods for solution of radiative heat transfer problems in non-participating and participating medium and applications of boiling and condensation in industry.	
CO5:	Demonstrate the importance of heat exchanger and its applications in industry.	

Mapping of COS and POs

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	1	-	1	1	1
CO2	3	2	1	-	1	1	1
CO3	3	2	1	2	1	1	1
CO4	3	2	1	-	1	1	1
CO5	3	2	1	2	1	1	1

	Steam and Gas Turbines			
	Course Code	MMTP202	CIE Marks	50
	Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
	Total Hours of Pedagogy	40	Total Marks	100
	Credits	03	Exam Hours	3 Hr

Course Learning objectives:

- To develop the ability to use the concepts of Nozzles and Diffusers for various applications in gas and steam turbines.
- To understand the working principle, operations and analysis of impulse and reaction steam turbines and its applications in steam power plant.
- To develop an intuitive understanding of state point locus of an impulse turbine and its various losses in turbines.
- To present a comprehensive and rigorous treatment of Axial and Centrifugal compressor and its applications in gas and jet propulsion cycles.

Module-1

Nozzles and diffusers: Introduction types of nozzles, types of Diffusers, Equation of Continuity Sonic Velocity and Mach Numbers, The Steady Flow Energy Equation in Nozzles, Gas Nozzles The Momentum Equation for the flow Through Steam Nozzles, Entropy Changes with friction, Nozzle Efficiency, The Effect of Friction on the Velocity of steam Leaving the Nozzles, Diffusion Efficiency, shape of Nozzle for Uniform Pressure Drop, Mass of Discharge of Critical Pressure in Nozzle Flow or Chocked Flow, Physical Explanation of Critical Pressure, Maximum Discharge of Saturated Steam, Maximum Discharge of Steam initially Superheated, Critical Pressure Ratio for Adiabatic and Frictionless Expansion of Steam from Ratio for Adiabatic and Frictionless Expansion of Steam from a given initial Velocity, Idea of Total or Stagnation Enthalpy and Pressure, General Relationship Between or Area Velocity and pressure in Nozzle Flow,Effect of Friction on Critical Pressure Ratio Critical Pressure Ratio in a Frictionally Resisted Expansion from a Given Initial Velocity, Supersaturated Flow in Nozzles, Effect of Variation of Back Pressure, Parameters Affecting the Performance of Nozzles, Experimental Methods to Determine Velocity Coefficient, Experimental Results.

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Module-2

Steam Turbines Types and Flow of Steam through Impulse Blades: Basic concepts, Principal of operation of turbine, Comparison of Steam Engines and Turbines, Classifications of Steam Turbine, compounding, Velocity Diagram for Impulse Turbines, Performance parameters of Impulse Turbine, 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. **Flow of Steam Through Impulse-Reaction Turbine Blades:** Velocity diagram, degree of reaction, impulse- reaction turbine with similar blade section and half degree reaction turbine, height of reaction turbine blading, effect of working steam on the stage efficiency of Parson's turbine, operation of impulse blading with varying heat drop or variable speed, impulse-reaction turbine section.	
	Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.
	Module-3	
	State Point Locus Reheat Factor and Design Procedure: Introduction, stage efficiency of impulse turbines, state point locus of an impulse turbine, reheat factor, internal and other efficiencies, increase in isentropic heat drop in a stage due to friction in proceeding stage, correction for terminal velocity, reheat factor for an expansion with the uniform adiabatic index and a constant stage efficiency, correction of reheat factor for finite number of stages, design procedure of impulse turbine, design procedure for impulse- reaction turbines. **Energy losses in turbines:** List of Energy Losses,Valve, nozzle, blade, Trailing edge wake, impingement, leakage losses. Blade friction, turning of steam jet, blade wind age losses, losses due to shrouding, Disc friction,radiation and conduction, mechanical losses, leakage through the end seals.	
	Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.
	Module-4	
	Centrifugal Compressors: Components of Centrifugal compressor, Principle of operation, Blade shapes and velocity triangles, Ideal and actual energy transfer, Slip Factor, Diffuser, Volute casing, Performance parameters, Surging and choking. **Axial Flow Compressors:**Description and principle of operation, Stage velocity triangle, work done factor, blading efficiency, performance coefficients, flow through blade rows, flow losses, performance characteristics, comparison of axial and centrifugal compressor.	
	Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.
	Module-5	
	Shaft power Cycles and Gas turbine cycles: Ideal cycles, the simple gas turbine cycles, closed cycle gas turbines, open cycle gas turbine with intercooler, reheater and regeneration, methods of accounting for component losses, design point performance calculations, Loss due to incomplete combustion, polytropic efficiency, performance of actual cycle, combined cycles and cogeneration schemes.	

	Jet Propulsion Cycles: The simple turbojet cycle, turbo fan engine, turbo prop engine, Ramjet engines, the pulse jet engines, thrust equations, efficiencies, parameters affecting flight performance, thrust augmentation.	
	Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of 25 Marks
2. Two assignments each of 25 Marks or one Skill Development Activity of 50 marksto attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be scaled down to 50 marks

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Steam and Gas Turbines - R. Yadav, Central Publishing House, Allahabad, 7th edition.
2. Gas Turbines - V. Ganesan, Tata McGraw-Hill Publications, 3rd edition.
3. Gas Turbine and Propulsive Systems – P.R. Khajuria, S. P. Dubey, Dhanpat rai publications, 5th edition 2012.

4. Gas Turbine Theory – H.I.H. Saravanamuttoo, G.F.C. Rogers & H Cohen, Pearson Education, 8th edition.
5. Elements of Gas Turbine Propulsion- Jack D Mattingley, McGraw-Hill Publications 1st edition.
6. Turbines compressors and fans – S. M. Yahya, Tata McGraw-Hill Publications, 4th edition.

Web links and Video Lectures (e-Resources):

- https://archive.nptel.ac.in/courses/112/107/112107216/
- https://archive.nptel.ac.in/courses/112/103/112103262/
- https://archive.nptel.ac.in/courses/112/103/112103277/

Skill Development Activities Suggested

Course outcome (Course Skill Set)

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

Sl. No.	Description	Bloo Lev
CO1	Describe the working principles of Gas and steam turbine nozzles and diffusers.	
CO2	Designate the working principles of impulse and reaction turbines using velocity triangles.	
CO3	Use the concepts of State Point Locus Reheat Factor and Identify the various losses associated with the turbines.	
CO4	Illustrate the concepts of axial flow and centrifugal compressors and its application in gas turbine.	
CO5	Explain the concepts of open and closed cycle gas turbine and its application in jet propulsion.	

Mapping of COS and POs

POs → COs↓	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**

CO1	**3**	**2**	**1**	**2**	**1**	**1**	**1**
CO2	**3**	**2**	**1**	**2**	**1**	**1**	**1**
CO3	**3**	**2**	**1**	**-**	**1**	**1**	**1**
CO4	**3**	**2**	**1**	**-**	**1**	**1**	**1**
CO5	**3**	**2**	**1**	**-**	**1**	**1**	**1**

Advanced Thermodynamics and Combustion

Course Code	MMTP203	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3 Hr

Course Learning objectives:

- To enhance the understanding of thermodynamics principles and their relevance to the problems of humankind.
- Provide the student with experience in applying thermodynamic principles to predict physical phenomena and to solve engineering problems.
- To clarify availability concept and analyze availability cycles.
- Understanding the fundamental of properties of gas mixtures, chemical reactions, and chemistry of combustion.

Module-1

Review of Basic Thermodynamics: First &Second Law Analysis, Review of entropy, Concept of entropy and entropy generation, Entropy balance for closed & open systems; Concept of exergy & irreversibility, Exergy analyses of open and closed system.

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Module-2

Thermodynamic Property Relations: Maxwell relations; Relations involving enthalpy, internal energy, and entropy; Mayer relation, Clausius-Clapeyron equation, Joule-Thompson experiment.
Properties of Gas Mixtures: Composition of Gas mixtures: Mass and Mole fractions: P-V-T behaviour of Gas mixtures Ideal and Real gases. Equations of statesand properties of ideal and real gas mixtures, Property relations for mixtures and Psychrometry, Change in entropy in mixing.

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Module-3

Chemical Reactions: Fuels and combustion, Theoretical and actual combustion processes, Enthalpy of formation and enthalpy of combustion, first law analysis of reacting systems, Adiabatic flame temperature, Entropy change of Reacting systems, second law analysis of reacting systems.

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Module-4

Concept of Chemical Equilibrium: Criterion for Chemical equilibrium, Gibbs free energy and the equilibrium constant of a chemical reaction (Vant-Hofts equation). Calculation of equilibrium, Composition of a chemical reaction.
Chemistry of Combustion: Combustion Kinetics, Detailed combustion Kinetics, simplified combustion kinetics. Physics of Combustion:Fundamental laws of transport phenomena, Conservations Equations, Transport in Turbulent Flow.

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Module-5

Combustion and Flames: Premixed Flame, laminar premixed flames, burning velocity measurement methods, Effects of chemical and physical variables on Burning velocity, Turbulent Premixed Flames, Laminar Diffusion Flames, Turbulent Diffusion Flames, Turbulent Mixing, Liquid fuel combustion, Atomization, Spray Combustion, Solid fuel combustion.

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of 25 Marks
2. Two assignments each of 25 Marks or one Skill Development Activity of 50 marksto attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be scaled down to 50 marks
CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:
Textbooks

1. M. J. Moran, H. N. Shapiro, D. D. Boettner and M. B. Bailey, Principles of Engineering Thermodynamics, Eighth Edition, Wiley, New Delhi, 2015
2. Y. U. Cengel and M. A. Boles, Thermodynamics: An Engineering Approach, Fourth Edition, Tata McGraw-Hill, New Delhi, 2003

3. R. H. Dittman and M. W. Zemansky, Heat and Thermodynamics, Seventh Edition, Tata McGraw-Hill, New Delhi, 2007
4. S. R. Turns, An Introduction to Combustion: Concepts and Applications, McGraw Hill International Edition, Singapore, 200
5. K. K. Kuo, Principles of Combustion, Second Edition, Wiley India Pvt. Ltd., New Delhi, 2012
6. Modern Engineering Thermodynamics, Robert Balmer, Elsevier.
7. Advanced Thermodynamics for Engineers, Kenneth Wark, McGraw Hill.

Web links and Video Lectures (e-Resources):

https://archive.nptel.ac.in/courses/112/103/112103307/
https://archive.nptel.ac.in/courses/112/103/112103313/
https://archive.nptel.ac.in/courses/112/106/112106310/
https://archive.nptel.ac.in/courses/103/103/103103162/
https://archive.nptel.ac.in/courses/103/104/103104151/

Skill Development Activities Suggested

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Illustrate the basic concepts on First & Second Law Analysis,entropy, and exergy analysis in thermodynamic systems.	
CO2	Analyse the Thermodynamic property relations and its application to gas mixtures, phase change processes.	
CO3	Demonstrate the Combustion fundamentals involving premixed and non-premixed flames for laminar and turbulent combustion.	
CO4	Explain thefundamental of properties of gas mixtures, chemical reactions, and chemistry of combustion.	
CO5	Applications ofCombustion phenomena in practical occurring applications such IC and GT engines.	

Mapping of COS and POs

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	1	-	1	1	1
CO2	3	2	1	-	1	1	1
CO3	3	2	1	2	1	1	1
CO4	3	2	1	-	1	1	1
CO5	3	2	1	2	1	1	1

Finite Element Method in Heat Transfer			
Course Code	MMTP214A	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3 Hr

Course objectives:

- The basic concepts of Finite Element methods and its applications to thermal engineering problems.
- The Formulation of Heat Conduction Equations and its Application to Heat Transfer Problems.
- The application of the FEM technique to Nonlinear Heat conduction Analysis, Convective Heat Transfer and Fluid Mechanics Problems.

MODULE-1

Introduction: Historical Perspective of FEM and applicability to Thermal Engineering problems, Types of Governing Equations for Heat Conduction, Initial, boundary and interface conditions, Approximate methods, Rayleigh – Ritz Methods and Galerkin's methods, Different Approaches in FEM, Some Basic Discrete Systems (Heat Conduction and Fluid flow network), Numerical Problems.

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

MODULE-2

Finite Element Formulations: Formulation of one dimensional linear and Quadratic element characteristic matrices and vectors. Assembly considerations and boundary conditions, Quadratic elements and their advantages and disadvantages, Two dimensional elements; triangular and quadrilateral elements with parametric representation, Higher order elements, Sub parametric, super parametric and Iso-parametric elements, Problems with one and two dimensional linear and Quadratic elements.

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

MODULE-3

Formulation of Heat Conduction Equations: The Variational method and method of weighted residuals of finite element equation for 3-D heat conduction, Requirements for Interpolation Functions.
Steady State Heat Conduction in One Dimension: Heat conduction in Plain walls, Radial Heat Flow in a Cylinder, Conduction–Convection Systems, Two-dimensional Plane Problems, Axisymmetric Problems, Three-dimensional Heat Transfer Problems.

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

MODULE-4

Application to Heat Transfer Problems: Straight uniform fin analysis with convection heat loss, Tapered Fin, Fin analysis with quadratic elements.

Nonlinear Heat conduction Analysis: Lumped Heat Capacity System, Galerkin's method to nonlinear transient heat conduction; Governing equation with initial and boundary conditions, One dimensional nonlinear steady-state problems.	
Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.
MODULE 5	
Convective Heat Transfer: Basic equations, steady convection diffusion problems and transient convection-diffusion problems, Characteristic-based Split (CBS) Scheme. **Applications to Fluid Mechanics Problems:** Inviscid and Incompressible flows, Viscous and Non-Newtonian Flows, Stream Function Formulation (using Variational method), Velocity-pressure-formulation (using Galerkin's method). Examples of heat transfer in a fluid flowing between parallel planes.	
Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of 25 Marks
2. Two assignments each of 25 Marks or one Skill Development Activity of 50 marksto attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be scaled down to 50 marks
CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Fundamentals of the Finite Element Method for Heat and Fluid Flow: Roland W. Lewis, Perumal Nithiarasu, Kankanhalli N. Seetharamu: John Wiley & Sons Ltd,2004 ISBN:9780470847886
2. Finite element Method in Engineering: Singiresu S. Rao: 5th Edition, Elsevier, 2012.
3. The Finite Element Method in Heat Transfer and Fluid dynamics: Reddy J.N., Gartling. D.K.: 3rd Edition, CRC Press Taylor & Francis Group, 2010.
4. The Finite Element Method: Zeincowicz: 4 Vol set. 4th Edition, Elsevier 2007.
5. The finite element method in heat transfer analysis - R.W. Lewis, K Morgan, H.R. Thomas, K.N. Seetharamu, John Wiley and Sons,1996.

Web links and Video Lectures (e-Resources):

http://nptel.ac.in/courses/112104116/
https://archive.nptel.ac.in/courses/112/105/112105308/
https://archive.nptel.ac.in/courses/112/103/112103295/
https://archive.nptel.ac.in/courses/112/104/112104116/
https://archive.nptel.ac.in/courses/112/104/112104115/#

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Recall Governing Equations for Heat Conduction for solving 1-D thermal problems using Approximate methods, Rayleigh – Ritz Methods and Galerkin's methods.	
CO2	Formulate the element characteristic for linear and Quadratic matrices and vectors for1-D and 2-D problems.	
CO3	Explain the Formulation of Heat Conduction Equations for 1D, 3-D, Fin, and Nonlinear Heat conduction for developing mathematical models.	
CO4	Demonstrate the Application of numerical methods on heat transfer problems, Convective Heat Transfer and Fluid Mechanics Problems.	

Mapping of COS and POs

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	1	2	2	1	1
CO2	3	2	1	2	2	1	1
CO3	3	2	1	2	2	1	1

CO4	**3**	**2**	**1**	**2**	**2**	**1**	**1**

Advanced Power Plant Cycles			
Course Code	**MMTP214B**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3 Hr

Course Learning objectives:

- The objective of the subject is to acquaint the students about the new and advanced technologies of power generation.
- To study the power generation scenario, the components of thermal power plant, improved Rankin cycle, Cogeneration cycle.
- To understand details of steam condensing plant, analysis of condenser, the environmental impacts of thermal power plant, method to reduce various pollution from thermal power plant.
- To study layout, component details of hydroelectric power plant, hydrology and elements, types of nuclear power plant.

Module-1

Analysis of Steam cycles: Rankine cycle, Carnot cycle, mean temperature of heat addition, effect of variation of steam condition on thermal efficiency 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 power cycle, Binary vapor cycles, coupled cycles, combined cycle plants, gas turbine- steam turbine power plant, MHD-steam power plant, Thermionic- Steam power plant.

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Module-2

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

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Module-3

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

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Module-4

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

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Module-5

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

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of 25 Marks
2. Two assignments each of 25 Marks or one Skill Development Activity of 50 marksto attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be scaled down to 50 marks CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Textbooks

1. Power Plant Engineering - P.K. Nag, Tata McGraw-Hill Publications. 2nd edition.
2. Power Plant Engineering - M.M. EI-Wakil, McGraw- Hill Publications. 1st edition.
3. Power plant engineering –R. K. Rajput, Laxmi Publications 3rd edition.
4. Gill, A.B., "Power Plant Performance", Butterworths, 1984.
5. Lamarsh, J.R., "Introduction to Nuclear", Engg.2nd edition, AddisonWesley, 1983.

Web links and Video Lectures (e-Resources):

- https://archive.nptel.ac.in/courses/112/107/112107291/
- https://archive.nptel.ac.in/courses/112/101/112101007/

Skill Development Activities Suggested:

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Describe the power generation scenario, the layout components of thermal power plant and analyze the improved Rankin cycle, Cogeneration cycle.	
CO2	Analyze the steam condensers, recognize the environmental impacts of thermal power plant and method to control the same.	
CO3	Recognize the layout, component details of hydroelectric power plant and nuclear power plant	
CO4	Describe the different power plant electrical instruments and basic principles of economics of power generation.	

Mapping of COS and POs

POs → COs↓	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	**3**	**2**	**1**	**2**	**1**	**1**	**1**
CO2	**3**	**2**	**1**	**2**	**1**	**1**	**1**
CO3	**3**	**2**	**1**	**-**	**1**	**1**	**1**
CO4	**3**	**2**	**1**	**-**	**1**	**1**	**1**

Alternative Fuels for IC Engines

Course Code	MMTP214C	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3 Hr

Course Learning objectives:

- To Understand the need of alternative fuels, environment impact, types of alternative fuels, preparation of alternative fuels
- To familiarize the students about engine alteration to use alternative fuels
- To understand the current status of alternative fuels

Module-1

Conventional Fuels: Introduction, Current fuel scenario and consumption, per capita consumption Indianscenario, 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.

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Module-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, Enginemodifications required, Performance andemission characteristics of alternative fuels in SI mode of

operation v/s gasoline operation.

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Module-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 andProducer gas in CI engines in dual fuel mode. Engine modifications required. Performance and emissioncharacteristics of alternative fuels (mentioned above) in Dual Fuel mode of operation v/s Dieseloperation.

	Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.
	Module-4	
	Biodiesels: What arebiodiesels Need of biodiesels, Properties of bio-diesels v/s Petro-diesel,Performance and emission characteristics of bio-diesels v/s Petro diesel operation. **Availability:** Suitability & Future prospects of these gaseous fuels in Indian context.	
	Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.
	Module-5	
	Environmental pollution: with conventional and alternate fuels, Pollution control methods andpackages. Euro norms, Engine missions, Emission control methods, EPA. Air quality emission standards	
	Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of 25 Marks
2. Two assignments each of 25 Marks or one Skill Development Activity of 50 marksto attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be scaled down to 50 marks

CIE methods /question paper is designed to attain the different levels of Bloom’s taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.

4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

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 Inter science Publications.
6. Internal Combustion Engines - V. Ganesan, Tata McGraw-Hill Publications.
7. M.K. Gajendra Babu, K.A. Subramanian, Alternative Transportation Fuels: Utilization in
Combustion Engines, CRC Press, 2013.
8. Richard L. Bechfold, Alternative Fuels Guidebook - SAE International Warrendale 1997.

Web links and Video Lectures (e-Resources):

Skill Development Activities Suggested

Course outcome (Course Skill Set)

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

Sl. No.	Description	Bloo Lev
CO1	Explain about the availability and usage of conventional fuels for IC engines.	
CO2	Identify possible alternative fuels for IC engines.	
CO3	Demonstrate the use of alternative fuels for different types of engines	
CO4	Assess the environmental impact standards and procedures of using alternate fuels.	
CO5	Describe and analyze Need for alternative fuels such as Ethanol, Methanol, LPG, CNG, Hydrogen and their manufacturing procedure.	

Mapping of COS and POs

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	1	2	1	1	1

CO2	**3**	**2**	**1**	**2**	**1**	**1**	**1**
CO3	**3**	**2**	**1**	**-**	**1**	**1**	**1**
CO4	**3**	**2**	**1**	**-**	**1**	**1**	**1**
CO5	**3**	**2**	**1**	**-**	**1**	**1**	**1**

Non-Conventional Energy Sources

Course Code	MMTP214D	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3 Hr

Course Learning objectives:

- To provide a survey of the most important renewable energy resources and the technologies for harnessing these resources within the framework of a broad range of simple to state- of -the-art energy systems.
- To create awareness about sources of energy and able to estimate how long the available conventional fuel reserves will last.
- To learn the fundamental concepts about solar energy systems and devices.
- To design wind turbine blades and know about applications of wind energy for water pumping and electricity generation.
- To understand the working of OTEC system and different possible ways of extracting energy from ocean, know about Biomass energy, mini-micro hydro systems and geothermal energy system.

Module-1

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

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Module-2

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

	Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.
	Module-3	
	Wind Energy: Properties of wind, availability of wind energy in India, wind velocity and power from wind; major problems associated with wind power, wind machines; Types of wind machines and their characteristics, horizontal and vertical axis wind mills, elementary design principles; coefficient of performance of a wind mill rotor, aerodynamic considerations of wind mill design, numerical examples.	
	Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.
	Module-4	
	Tidal Power: Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, harnessing tidal energy, limitations. Ocean Thermal Energy Conversion: Principle of working, Rankine cycle, OTEC power stations in the world, problems associated with OTEC.	
	Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.
	Module-5	
	Geothermal Energy Conversion: Principle of working, types of geothermal station with schematic diagram, geothermal plants in the world, problems associated with geothermal conversion, scope of geothermal energy. Energy from Bio Mass: Photosynthesis, photosynthetic oxygen production, energy plantation, bio gas production from organic wastes by anaerobic fermentation, description of bio-gas plants, transportation of biogas, problems involved with bio-gas production, application of bio-gas, application of bio-gas in engines, advantages	
	Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of 25 Marks
2. Two assignments each of 25 Marks or one Skill Development Activity of 50 marksto attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be scaled down to 50 marks

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

TEXT BOOK

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

Web links and Video Lectures (e-Resources):

https://archive.nptel.ac.in/courses/121/106/121106014/
https://drive.google.com/file/d/1TezxsWvbHDda45wGLHt7vDS5zFv7kd56/view

Skill Development Activities Suggested

Course outcome (Course Skill Set)

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

Sl. No.	Description	Bloo Lev

CO1	Demonstrate the generation of electricity from various Non-Conventional sources of energy, have a working knowledge on types of fuel cells.		
CO2	Estimate the solar energy, Utilization of it, Principles involved in solar energy collection and conversion of it to electricity generation.		
CO3	Explore the concepts involved in wind energy conversion system by studying its components, types and performance.		
CO4	Illustrate ocean energy and explain the operational methods of their utilization.		
CO5	Acquire the knowledge on Geothermal energy.		

Mapping of COS and POs

POs → COs↓	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	**3**	**2**	**1**	**1**	**2**	**1**	**1**
CO2	**3**	**2**	**1**	**2**	**2**	**1**	**1**
CO3	**3**	**2**	**1**	**2**	**2**	**1**	**1**
CO4	**3**	**2**	**1**	**2**	**2**	**1**	**1**
CO5	**3**	**2**	**1**	**-**	**1**	**1**	**1**

Refrigeration and Air Conditioning

Course Code	MMTP215A	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3 Hr

Course Learning objectives:

- To provide the sufficient knowledge of concept, applications, importance of refrigeration.
- To familiarize the students about the refrigeration processes and component design.
- To provide the understanding of the industrial applications of refrigeration.

Module-1

Refrigeration cycles – analysis: Development of Vapor Compression Refrigeration Cycle from Reverse Carnot Cycle- conditions for high COP-deviations from ideal vapor compression cycle, Multi pressure Systems, Cascade Systems-Analysis. Main system components: Compressor- Types, performance, Characteristics of Reciprocating Compressors, Capacity Control, Types of Evaporators & Condensers and their functional aspects, Expansion Devices and their Behavior with fluctuating load.

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Module-2

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

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Module-3

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

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

	Module-4	
	Load estimation & air conditioning control: Solar Radiation-Heat Gain through Glasses, Heat transfer through roofs and walls, Total Cooling Load Estimation. Controls of Temperature, Humidity and Airflow.	
	Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.
	Module-5	
	Air distribution: Flow through Ducts, Static & Dynamic Losses, Air outlets, Duct Design–Equal, Friction Method, Duct Balancing, Indoor Air Quality, Thermal Insulation, Fans & Duct System Characteristics, Fan Arrangement Variable Air Volume systems, Air Handling Units and Fan Coil units. Central air condition systems.	
	Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of 25 Marks
2. Two assignments each of 25 Marks or one Skill Development Activity of 50 marksto attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be scaled down to 50 marks

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

Textbook

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.

Reference Books

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

Web links and Video Lectures (e-Resources):

- https://archive.nptel.ac.in/courses/112/107/112107208/
- https://archive.nptel.ac.in/courses/112/105/112105128/
- https://archive.nptel.ac.in/courses/112/105/112105129/
- https://drive.google.com/file/d/1sNh-s8Nk4S_tWvOXQJLobbZJrLwbEuLi/view

Skill Development Activities Suggested

Course outcome (Course Skill Set)

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

Sl. No.	Description	Bloo Lev
CO1	Understand concepts of refrigeration and air-conditioning process and systems.	
CO2	Employ the theoretical principles to simple, complex vapour compression and vapour absorption refrigeration systems.	
CO3	Understand conventional and alternate refrigerants and their impact on environment.	
CO4	Apply the heat load calculation to design the air-conditioning systems.	

CO5	Describe the concepts to design air distribution systems.		

Mapping of COS and POs

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	1	2	1	1	1
CO2	3	2	1	2	1	1	1
CO3	3	2	1	-	1	1	1
CO4	3	2	1	-	1	1	1
CO5	3	2	1	-	1	1	1

Hydrogen and Fuel Cell Technologies			
Course Code	MMTP215B	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3 Hr

Course Learning objectives:

- Provide thorough understanding of performance characteristics of fuel cell power plant and its components.
- Outline the performance and design characteristics and operating issues for various fuel cells.
- Discuss the design philosophy and challenges to make this power plant economically feasible.
- The design and analysis emphasis will be on the thermodynamics and electrochemistry. Thus, at the successful end of the course, the students will have sufficient knowledge for working in a fuel cell industry or R&D organization.

Module-1

Hydrogen: Production of hydrogen, Hydrogen conversion overview, Hydrogen storage options, Hydrogen transmission, Problems.

Hydrogen Distribution Infrastructure for an Energy System: Hydrogen Transport by Gaseous Pipelines, Hydrogen Transport by Road, Alternative Hydrogen Delivery Systems, Stationary Bulk Storage of Hydrogen, Supporting Technologies, Hydrogen Fueling Stations.

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Module-2

Fuel Cells Technology Overview: Basic Structure, Critical Functions of Cell Components, Cell Stacking, Fuel Cell Systems, Fuel Cell Types, Characteristics, Advantages/Disadvantages, Applications, Demonstrations, And Status.

Fuel cells: Basic concepts, Molten carbonate cells, Solid oxide cells, Acid and alkaline cells, Proton exchange membrane cells, Direct methanol and other non-hydrogen cells, Biofuel cells, Problems.

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Module-3

	Fuel Cell Performance: The Role of Gibbs Free Energy and Nernst Potential Ideal Performance Cell Energy Balance Cell Efficiency Actual Performance Fuel Cell Performance Variables Mathematical Models.	
	Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.
	Module-4	
	Fuel Cell Systems: System Processes, Fuel Processing, Power Conditioning, System Optimization, Fuel Cell System Designs, Fuel Cell Networks, Hybrids, Fuel Cell Auxiliary Power Systems	
	Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.
	Module-5	
	Fuel Cell Applications: Passenger cars, Bus, lorry, Ships, trains and airplanes, Power plants including stand-alone systems, Building-integrated systems, Portable and other small-scale systems, Problems and discussion topics	
	Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of 25 Marks
2. Two assignments each of 25 Marks or one Skill Development Activity of 50 marksto attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be scaled down to 50 marks

CIE methods /question paper is designed to attain the different levels of Bloom’s taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.

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

Suggested Learning Resources:

Books

1. Hydrogen and Fuel Cells: Fundamentals, Technologies and Applications; Detlef Stolten
2. Hydrogen and Fuel CellTechnologies and Market Perspectives; Johannes Töpler, Jochen Lehmann; Springer Berlin, Heidelberg
3. Hydrogen and Fuel Cells: Emerging Technologies and Applications; Inde Sorensen, Bent,2nd Edition - Elsevier
4. M.M. MENCH, Fuel Cell Engines, Wiley, 2008.
5. M. T. M. Koper (ed.), Fuel Cell Catalysis, Wiley, 2009.
6. J. O'M. Bockris, A. K. N. Reddy, Modern Electrochemistry, Springer 1998.
7. Larminie J., Dick A., Fuel Cell Systems Explained, 2nd Ed. Wiley, 2003.

Web links and Video Lectures (e-Resources):

- https://archive.nptel.ac.in/courses/103/101/103101215/
- https://archive.nptel.ac.in/courses/103/102/103102015/

Skill Development Activities Suggested

Course outcome (Course Skill Set)

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

Sl. No.	Description	Bloo Lev
CO1	Apply know-how of thermodynamics, electrochemistry, heat transfer, and fluid mechanics principles to design and analysis of this emerging technology.	
CO2	Have thorough understanding of performance behaviour, operational issues and challenges for all major types of fuel cells.	
CO3	Identify, formulate, and solve problems related to fuel cell technology keeping in mind economic viability.	
CO4	Use the techniques, skills, and modern engineering tools necessary for design and analysis of innovative fuel cell systems.	
CO5	Understand the impact of this technology in a global and societal context. Develop enough skills to design systems or components of fuel cells.	

Mapping of COS and POs

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7

CO1	**3**	**2**	**1**	**2**	**1**	**1**	**1**
CO2	**3**	**2**	**1**	**2**	**1**	**1**	**1**
CO3	**3**	**2**	**1**	**-**	**1**	**1**	**1**
CO4	**3**	**2**	**1**	**-**	**1**	**1**	**1**
CO5	**3**	**2**	**1**	**-**	**1**	**1**	**1**

Theory and Design of Modern IC Engine			
Course Code	MMTP215C	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3 Hr

Course objectives:

1. To provide the sufficient knowledge of concept, applications, importance of IC engines.
2. To understand the mechanism of combustion in SI and CI engine and its effect on engine performance.
3. To familiarize the students about the IC engines systems, processes, alternative fuels etc.
4. Knowledge ofdifferent Injection Systems and Engine emissions and their control.

MODULE-1

Introduction to IC Engines: Basic engine components and nomenclature, Applications of IC Engines**,** Engine characteristics, geometrical properties of reciprocating engines, specific emissions and emission index, relationships between performance parameters, Engine design and performance data. Energy flow through IC engines, Various Auxiliary systems. Environment friendly engines. Fuel –Air and Actual Engines: Modelling 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.

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

MODULE-2

Combustion in SI engine: Introductions, Ignition limits, Stages of Combustion in SI Engine, Effect of Engine Variables on Ignition lag, Effect of Engine variable on flame propagation, Detonation on knocking, Abnormal combustion knock-surface ignition, Cyclic variations in combustion, partial burning, and misfire, SI Engine combustion chamber designs, Combustion chamber design principles.

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

MODULE-3

Combustion in CI engine: Introduction, Combustion in the CI engine, Types of diesel Combustion Systems, Air-Fuel ration in CI Engines, Ignition Delay, Variables affecting delay period, Analysis of cylinder pressure Data, Fuel Spray Behaviour, The CI engine Combustion Chamber.

Alternate fuels for IC engines: Vegetable oils, alcohol, LPG, CNG, Hydrogen fuels, Biogas, Dual fuels, other possible fuels.

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

MODULE-4

Carburetion: Introduction, Factors affecting carburetion, mixture requirements at different load and speed, principles of carburetion, essential parts, and functions of a carburettor, 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.	
Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.
MODULE 5	
Engine emissions and their control: Air pollution due to IC engines, emission characteristics, Euro norms, engine emissions, Hydrocarbon emissions, CO emission, NOx- Photo chemical smog, Particulates, other emissions, Smoke, emission control methods – thermal converters, catalytic converters, particulate traps, Ammonia injection systems, exhaust gas recirculation, ELCD, Crank case blow by control. IC engine Noise characteristics, types, standards and control methods, Air quality emission standards **Measurement:** Noise, Emission, Pressure, crank angle torque, valve timings, temperature, and flow measurements.	
Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of 25 Marks
2. Two assignments each of 25 Marks or one Skill Development Activity of 50 marksto attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be scaled down to 50 marks CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.

The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. John B Heywood, ―IC Engines fundamentals‖, McGraw- Hill Publications,2011.
2. V. Ganesan, ―Internal Combustion Engines‖, Tata McGraw-Hill Publications, 4th Edition.
3. Internal Combustion Engines, Mathur R.P. & Sharma M.L., Dhanpat Rai Publication, 2014.
4. Richard stone, "Introduction to IC Engines" Palgrave Publication 3rd edition.
5. The Internal Combustion Engines in Theory and practice, Taylor C.F., MIT Press, 1985.

Web links and Video Lectures (e-Resources):

https://archive.nptel.ac.in/courses/112/103/112103262/

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	To explore the knowledge of performance parameters and its characteristics, variables effect the performance of engine and methods of improving engine performance of internal combustion engine.	
CO2	Analyze combustion and apply remedial measures to avoid abnormal combustion in SI and CI Engine.	
CO3	Specify and interpret data of alternative fuels and its emission which effect the environment.	
CO4	Analyze different electronic fuel injection system, supercharging and its effect on performance of SI and CI engine.	
CO5	Apply various emission control system and modification to take corrective actions to reduce pollution.	

Mapping of COS and POs

POs → COs↓	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	**3**	**2**	**1**	**-**	**-**	**1**	**1**
CO2	**3**	**2**	**1**	**2**	**-**	**1**	**1**
CO3	**3**	**2**	**1**	**2**	**-**	**1**	**1**
CO4	**3**	**2**	**1**	**2**	**-**	**1**	**1**
CO5	**3**	**2**	**1**	**-**	**-**	**1**	**1**

Jet and Rocket Propulsion systems				
Course Code	**MMTP215D**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3 Hr

Course Learning objectives:

- To Understand the concept of gas dynamics.
- To familiarize the students about the Jet and rocket propulsion and its whole thermodynamics analysis.
- To understand the applications of Jet propulsion.

Module-1

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

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Module-2

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

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Module-3

SOLID PROPELLANT ROCKET ENGINE: internal ballistics, equilibrium motor operation and equilibrium pressure to various parameters. Transient and pseudo equilibrium operation, end burning and burning grains, grain design. Rocket motor hardware design. Heat

	transfer Thermal Engineering considerations in solid rocket motor design. Ignition system, simple pyro devices. Liquid Rocket Propulsion System: Liquid propellants – classification, Mono and Bi propellants, Cryogenic and storage propellants, ignition delay of hypergolic propellants, physical and chemical characteristics of liquid propellant. Liquid propellant rocket engine – system layout, pump and pressure feed systems, feed system components. Design of combustion chamber, characteristic length, constructional features, and chamber wall stresses. Heat transfer and cooling aspects. Uncooled engines, injectors – various types, injection patterns, injector characteristics, and atomization and drop size distribution, propellant tank design.	
	Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.
	Module-4	
	TURBO JET PROPULSION SYSTEM: Gas turbine cycle analysis –layout of turbo jet engine. Turbo machinery- compressors and turbines, combustor, blade aerodynamics, engine off design performance analysis. Flight Performance: Forces acting on vehicle – Basic relations of motion – multistage vehicles	
	Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.
	Module-5	
	RAMJET AND INTEGRAL ROCKET RAMJET PROPULSIONSYSTEM: Fuel rich solid propellants, gross thrust, gross thrust coefficient, combustion efficiency of ramjet engine, air intakes and their classification – critical, super critical and sub-critical operation of air intakes, engine intake matching, classification, and comparison of IIRR propulsion systems.	
	Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Assessment Details (both CIE and SEE)

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Continuous Internal Evaluation:

1. Two Unit Tests each of 25 Marks
2. Two assignments each of 25 Marks or one Skill Development Activity of 50 marksto attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be scaled down to 50 marks

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Fundamentals of Aircraft and Rocket Propulsion; Ahmed F. El-Sayed; Springer-Verlag London 2016.
2. Fundamentals of Rocket Propulsion; D.P. Mishra; CRC Press Taylor & Francis Group2017.
3. Gas Turbines and Jet and Rocket Propulsion; Dr. M.L. Mathur and R.P. Sharma; Standard Publishers DistributorsEdition 2014.
4. Rocket Propulsion Elements; George P. Sutton, Oscar Biblarz; Ninth Edition John Wiley & Sons, Inc., Hoboken, New Jersey 2017.
5. Gas Turbines; V Ganesan; 3rd Edition2017; McGraw Hill Education.

Web links and Video Lectures (e-Resources):

- https://archive.nptel.ac.in/courses/101/104/101104019/
- https://archive.nptel.ac.in/courses/112/103/112103262/

Skill Development Activities Suggested

Course outcome (Course Skill Set)

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

Sl. No.	Description	Bloo Lev
CO1	Understand the aero thermo chemistry of the combustion products.	
CO2	Apply knowledge of features and capabilities of chemical and non-chemical rocket propulsion systems.	

CO3	Apply the concepts to ramjet ant jet propulsion system.		
CO4	Calculate the specific impulse and mass flow for a rocket engine with the fluid considered as an ideal gas with constant specific heats.		
CO5	Estimate the specific impulse and mass flow for a rocket engine accounting for chemical reaction and non-constant specific heats.		

Mapping of COS and POs

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**3**	**2**	**1**	**2**	**1**	**1**	**1**
CO2	**3**	**2**	**1**	**2**	**1**	**1**	**1**
CO3	**3**	**2**	**1**	**-**	**1**	**1**	**1**
CO4	**3**	**2**	**1**	**-**	**1**	**1**	**1**
CO5	**3**	**2**	**1**	**-**	**1**	**1**	**1**

Design of Heat Transfer Equipment's			
Course Code	MMTP206	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3 Hr

Course Learning objectives:

- To provide the sufficient knowledge of concept, applications, importance of thermal design of Heat exchanger.
- To familiarize the students about the heat exchanger design and its applications in real life situations.
- To carry out a computer simulation of heat exchanger design.

Module-1

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

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Module-2

DOUBLE PIPE HEAT EXCHANGER: Film coefficient for fluids in annulus, fouling factors, Calorific temperature, Average fluid temperature, The calculation of double pipe exchanger, Double pipe exchangers in series parallel arrangements.

Shell & Tube Heat Exchangers: Tube layouts for exchangers, Baffle heat exchangers, Calculation of shell and tube heat exchangers, Shell side film coefficients, Shell side equivalent diameter, The true temperature difference in a 1-2 heat exchanger. Influence of approach temperature on correction factor. Shell side pressure drop, Tube side pressure drop, Analysis of performance of 1-2 heat exchanger and design of shell & tube heat exchangers, Flow arrangements for increased heat recovery, the calculation of 2-4 exchangers.

Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Module-3

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

	Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.
	Module-4	
	VAPORIZERS, EVAPORATORS AND REBOILERS: Vaporizing processes, forced circulation vaporizing exchanger, Natural circulation vaporizing exchangers, Calculations of a re-boiler. Extended Surfaces: Longitudinal fins. Weighted fin efficiency curve, Calculation of a Double pipe fin efficiency curve. Calculation of a double pipe finned exchanger, Calculation of a longitudinal fin shell and tube exchanger.	
	Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.
	Module-5	
	DIRECT CONTACT HEAT EXCHANGER: Cooling towers, relation between wet bulb & dew point temperatures, The Lewis number and Classification of cooling towers, Cooling tower internals and the roll of fill, Heat Balance. Heat Transfer by simultaneous diffusion and convection, Analysis of cooling tower requirements, Deign of cooling towers, Determination of the number of diffusion units, Calculation of cooling tower performance.	
	Teaching-Learning Process	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.

Assessment Details (both CIE and SEE)

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CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.

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4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

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

Web links and Video Lectures (e-Resources):

- https://archive.nptel.ac.in/courses/103/105/103105210/
- https://archive.nptel.ac.in/courses/103/107/103107207/

Skill Development Activities Suggested

Course outcome (Course Skill Set)

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

Sl. No.	Description	Bloo Lev
CO1	Understand the physics and the mathematical treatment of typical heat exchangers and employ LMTD and Effectiveness methods in the design of heat exchangers	
CO2	Design, analyze and examine the performance of double-pipe counter flow (hair-pin) and shell and tube heat exchanger	
CO3	Understand the fundamental, physical and mathematical aspects of and condensation.	
CO4	Demonstrate the importance of Vaporizers, Evaporators and Reboilers as heat exchangers	
CO5	Classify cooling towers and explain their technical features.	

Mapping of COS and POs

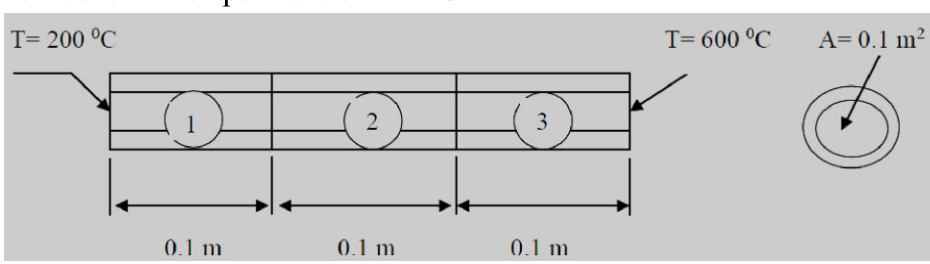
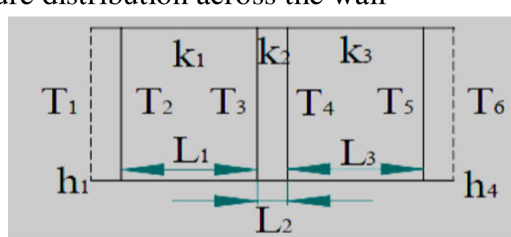
POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	1	2	1	1	1
CO2	3	2	1	2	1	1	1

CO3	**3**	**2**	**1**	**-**	**1**	**1**	**1**
CO4	**3**	**2**	**1**	**-**	**1**	**1**	**1**
CO5	**3**	**2**	**1**	**-**	**1**	**1**	**1**

FEM & Simulation Lab			
Course Code	MMTPL207	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	1:2:0	SEE Marks	50
Credits	2	Exam Hours	3 hr

Course objectives:

- The basic concepts of Finite Element methods and its applications to thermal engineering problems using ANSYS.
- The Formulation of Heat Conduction Equations and its Application to Heat Transfer Problems solve using ANSYS.
- The application of the FEM technique to Nonlinear Heat conduction Analysis, Convective Heat Transfer and Fluid Mechanics Problems solves using ANSYS.

Sl.NO	Experiments
1	For the composite wall idealized by the 1-D model shown in figure below, determine the interface temperatures. For element 1, let K_1 = 5 W / m °C, for element 2, K_2 = 10 W / m °C and for element 3, K_3 = 15 W / m °C. The left end has a constant temperature of 200 °C and the right end has a constant temperature of 600 °C 
2	A furnace wall is made of inside silica brick (K=1.5 W /mK) and outside magnesia brick (k=4.9W/mK), each 10 cm thick. The inner and outer surfaces are exposed to fluids at temperatures of 820°C and 110°C respectively. The contact resistance is 0.001m^2 K/W the heat transfer co-efficient for inner and outer surfaces is equal to 35W/m^2 K. Find the heat flow through the wall per unit area per unit time and temperature distribution across the wall 
3	A composite wall consists of three materials as shown. The outer temperature is T_0 = 20 °C. Convection heat transfer takes place on the inner surface of the wall with T_∞ = 800°C and h = 25 W/m^2°C. Determine the temperature distribution in the wall. K_1 = 20 W/m°C, K_2 = 30 W/m°C, K_3 = 50 W/m°C, h = 25 W/m^2°C, T_∞ = 800°C.

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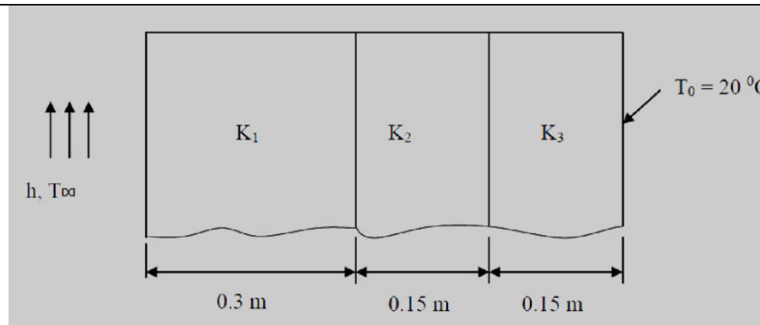

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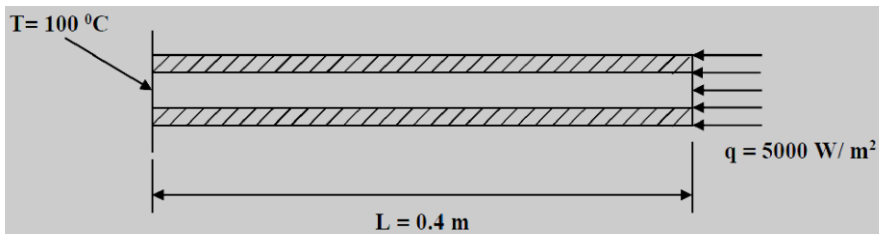
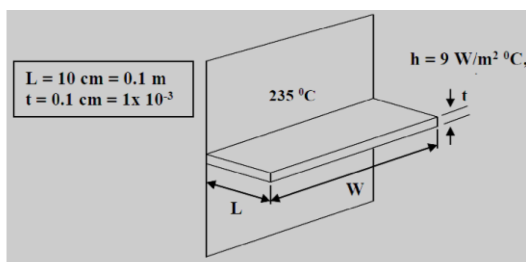
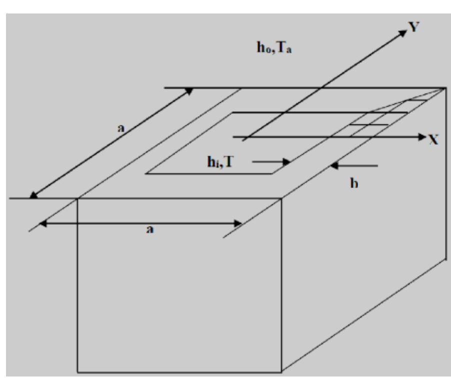
<tr><td>4</td><td>
The fin shown in figure is insulated on the perimeter. The left end has a constant temperature of 100°C. A positive heat flux q*= 5000 W / m2 acts on the right end. Let Kxx = 6 W/ m°C and cross sectional area A = 0.1 m2 . Determine the temperatures at and $\frac{L}{4}, \frac{L}{2}, \frac{3L}{4}, and\ L$ Where L = 0.4 m.



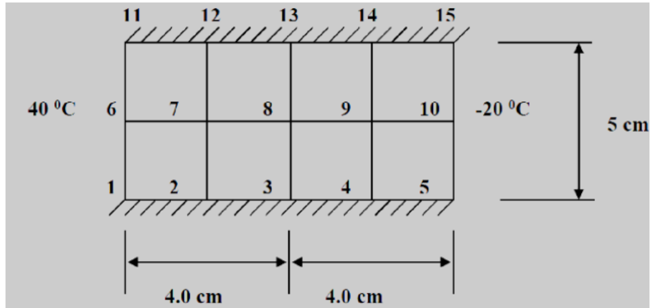
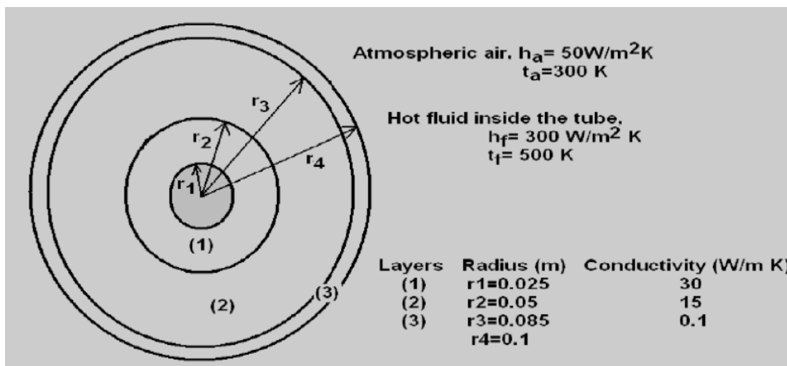
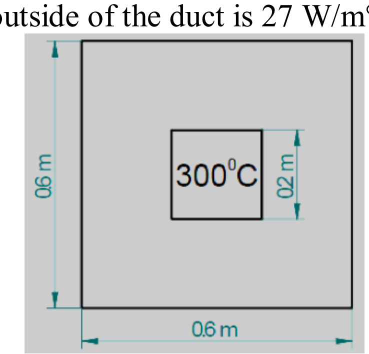
</td></tr>
<tr><td>5</td><td>
A metallic fin, with thermal conductivity Kxx = 360 W/m°C, 0.1 cm thick, and 10 cm long, extends from a plane wall whose temperature is 235°C. Determine the temperature distribution and amount of heat transferred from the fin to the air at 20°C with h = 9 W/m^2°C. Take the width of fin to be 1 m.

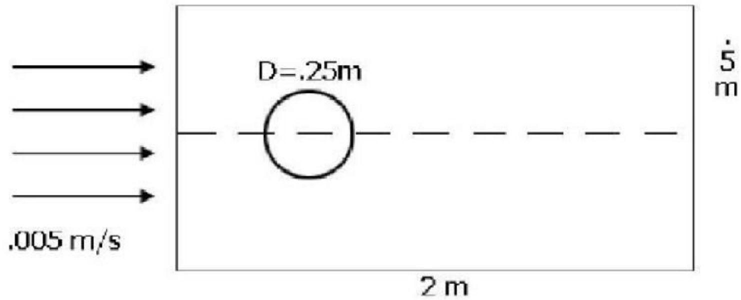
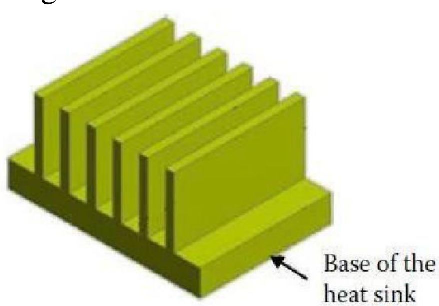
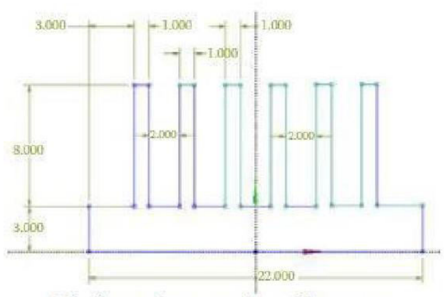


</td></tr>
<tr><td>6</td><td>
Determine the temperature distribution and the rate of heat flow "q" per metre of the height for a tall chimney whose cross section is shown below. Assume that the inside gas temp is T_g = 311 K, the inside convection coefficient is h_i, the surrounding air temp is T_a = 255 K and the outside convection coefficient is h_o.



</td></tr>
</table>

<table>
<tr><td>7</td><td>For the body shown in figure, determine the temperature distribution. The body is insulated along the top and bottom edges, Kxx = Kyy = 1.7307 W/m°C. No internal heat generation is present.

</td></tr>
<tr><td>8</td><td>Obtain the temperature distribution for the composite cylinder inside which a hot fluid is flowing, and the outer surface is exposed to surrounding atmospheric conditions as shown. Assume perfect continuity between the layers. Capture the temperature values at the interface of materials (Use an element size of 0.002m or less).

</td></tr>
<tr><td>9</td><td>The cross section of a 20 cm x 20 cm duct made of concrete walls 20 cm thick is shown in figure. The inside surface of the duct is maintained at a temperature of 300°C due to hot gases flowing from a furnace. On the outside the duct is exposed to air with an ambient temperature of 20°C. The heat conduction coefficient of concrete is 1.4 W/m°C. The average convection heat transfer coefficient on the outside of the duct is 27 W/m°C.

</td></tr>
<tr><td>10</td><td>Atmospheric air at 20°C flows with a velocity of 5 mm/s over a long horizontal cylinder of diameter 25 cm. Compute and plot the velocity distribution of air over the cylinder.</td></tr>
</table>

	
	Demonstration Experiments (For CIE) if any
11	Model Fully developed laminar flow and turbulent flow through a circular pipe using ANSYS Workbench
12	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.
13	Use a comprehensive model for combustion of fuel at atmospheric pressure and develop a computer program to estimate the heat released assuming a single step reaction using MATLAB Simulink.
14	Heat sinks are commonly used to enhance heat dissipation from electronic devices. In the case study, we conduct thermal analysis of a heat sink made of aluminum with thermal conductivity k = 170 W/(m K), density ρ = 2800 kg/m^3 , specific heat c = 870 J/(kg K), Young's modulus E = 70 GPa, Poisson's ratio ν = 0.3, and thermal expansion coefficient α = 22 × 10^{-6}/°C. A fan forces air over all surfaces of the heat sink except for the base, where a heat flux q′ is prescribed. The surrounding air is 28°C with a heat transfer coefficient of h = 30 W/(m^2 °C).   All dimensions are in millimeters. *Material*: Aluminum k = 170 W/(m · K) ρ = 2800 kg/m^3; c = 870 J/(kg · K) E = 70 GPa; ν = 0.3 α = 22 × 10^{-6}/°C *Boundary conditions*: Air temperature of 28°C; h = 30 W/(m^2 · °C). *Steady state*: q' = 1000 W/m^2 on the base. *Transient*: Square wave heat flux on the base. *Initial conditions:* Steady state: Uniform temperature of 28°C. Transient: Steady-state temperature results.

Course outcomes (Course Skill Set):

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

- CO1 Develop skills in making geometry and meshing for various configurations using ANSYS Workbench.
- CO2 Develop knowledge in CFD simulation of Convective heat transfer and phase change problems using ANSYS Workbench.
- CO3 Develop knowledge in simulation of lamina and turbulent flow using ANSYS Workbench.
- CO4 Develop MATLAB programme for simulation of IC engine performances.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each course. The student has to secure not less than 40% of maximum marks in the semester-end examination(SEE). In total of CIE and SEE student must secure 50% maximum marks of the course.

Continuous Internal Evaluation (CIE):

CIE marks for the practical course is **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment to be evaluated for conduction with observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled downed to 30 marks (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 02 tests for 100 marks, the first test shall be conducted after the 8th week of the semester and the second test shall be conducted after the 14th week of the semester.
- In each test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student’s performance and learning ability.
- The average of 02 tests is scaled down to **20 marks** (40% of the maximum marks).
- The Sum of **scaled-down** marks scored in the report write-up/journal and average marks of two tests is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

SEE marks for the practical course is 50 Marks.

SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the University. • All laboratory experiments are to be included for practical examination. • (Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners. • Students can pick one question (experiment) from the questions lot prepared by the internal /external examiners jointly. • Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners. • General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners) Change of experiment is allowed only once and 10% Marks allotted to the procedure part to be made zero. The duration of SEE is 03 hours
Suggested Learning Resources:

Ability /Skill Enhancement Courses

	Numerical Programming for Mechanical Engineers (Using MATLAB/NumPy)		Semester	02
	Course Code	**MMTP258A**	CIE Marks	50
	Teaching Hours/Week (L:T:P: S)	0:0:0:2	SEE Marks	50
	Total Hours of Pedagogy	15	Total Marks	100
	Credits	01	Exam Hours	1 Hour
	Examination type (SEE)	**MCQ**		

Note: Instead of MATLAB any equivalent open source and commercial software can be used

Course objectives:

By the end of this course, students will be able to:

1. Gain knowledge of basic numerical methods and algorithms used in mechanical engineering.
2. Understand the mathematical foundations and applications of numerical techniques.
3. Learn to use MATLAB and NumPy for numerical problem-solving in mechanical engineering contexts.
4. Familiarize with key concepts in solving linear and nonlinear equations, interpolation, and numerical differentiation.
5. Learn to apply numerical methods for mechanical engineering simulations and error analysis.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Hands-On Coding Assignments
2. Lab Sessions
3. Project-Based Learning
4. Interactive Demonstrations
5. Comparative Analysis
6. Visualizations
7. Regular Quizzes and Tests
8. Continuous Feedback and Assessment

Module-1

Introduction to Numerical Programming

Overview of Numerical Methods: Basic definitions and examples of numerical methods, Significance of numerical programming in engineering. **Introduction to MATLAB and NumPy:** Syntax, commands, and basic operations, Understanding variables, matrices, and vectors. **Basic Programming Constructs:** Loops, conditional statements, and functions, Debugging techniques in MATLAB/NumPy

Module-2

Solving Linear and Nonlinear Equations:

Linear Systems of Equations: Gaussian elimination, LU decomposition. **Iterative methods:** Jacobi and Gauss-Seidel. **Nonlinear Equations:** Bisection method, Newton-Raphson method, Fixed-point iteration

Module-3

Numerical Differentiation and Integration:

Numerical Differentiation: Forward and backward difference methods, Central difference approximation. **Numerical Integration:** Trapezoidal rule, Simpson's rule

Module-4

Interpolation and Curve Fitting:

Polynomial Interpolation: Lagrange and Newton interpolation methods, Application to curve fitting. **Least Squares Method:** Fitting a linear model to data points

Module-5

Numerical Solutions of Ordinary Differential Equations (ODEs)
Introduction to ODEs: Types of ordinary differential equations in mechanical engineering, Initial value and boundary value problems.
Numerical Methods for ODEs: **Euler's method, Runge-Kutta methods (4th order)**

Course outcome (Course Skill Set)
At the end of the course the student will be able to::
1. Identify the appropriate numerical method for a given engineering problem.
2. Understand and recognize various methods for solving equations, integration, and interpolation.
3. Select suitable algorithms for solving ODEs in mechanical engineering.
4. Evaluate the accuracy of numerical methods and identify common sources of error.
5. Apply numerical methods to basic mechanical engineering problems using MATLAB/NumPy.

Assessment Details (both CIE and SEE)
The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). The student is declared as a pass in the course if he/she secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together
Continuous internal Examination (CIE)

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examinations (SEE)
SEE paper shall be set for 50 questions, each of the 01 marks. The pattern of the question paper is MCQ (multiple choice questions). The time allotted for SEE is **01 hour.** The student has to secure a minimum of 35% of the maximum marks meant for SEE.

Suggested Learning Resources:
Books
1. **"Numerical Methods for Engineers"** by Steven C. Chapra and Raymond P. Canale
2. **"Applied Numerical Methods with MATLAB for Engineers and Scientists"** by Steven C. Chapra
3. **"Numerical Methods in Engineering with Python 3"** by Jaan Kiusalaas
4. **"MATLAB for Engineers"** by Holly Moore
5. **"Python for Engineers and Scientists"** by E.M. Kranakis

Web links and Video Lectures (e-Resources):

1. **MATLAB Documentation:** https://www.mathworks.com/help/matlab/
2. **NumPy Documentation:** https://numpy.org/doc/stable/
3. **MIT OpenCourseWare - Numerical Methods:** https://ocw.mit.edu/courses/mechanical-engineering/
4. **Coursera - Numerical Methods for Engineers:**https://www.coursera.org/learn/numerical-methods-engineering
5. **SciPy Documentation (for advanced numerical computing):** https://docs.scipy.org/doc/scipy/

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Collaborative Learning
- Gamification of Learning
- Online Code Repositories

	Python Programming for Beginners		Semester	02
	Course Code	MMTP258B	CIE Marks	50
	Teaching Hours/Week (L:T:P: S)	0:0:0:2	SEE Marks	50
	Total Hours of Pedagogy		Total Marks	100
	Credits	01	Exam Hours	1 Hour
	Examination type (SEE)	MCQ		

By the end of this course, students will be able to:
1. Understand the fundamentals of Python programming, including variables, control structures, and data types.
2. Develop basic Python scripts to solve computational problems.
3. Understand and use functions, libraries, and modules to enhance programming capabilities.
4. Learn to work with files and handle exceptions in Python.
5. Apply Python programming skills to solve practical, real-world problems in mechanical engineering and other domains.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.
1. Hands-On Coding Assignments
2. Lab Sessions
3. Project-Based Learning
4. Interactive Demonstrations
5. Comparative Analysis
6. Visualizations
7. Regular Quizzes and Tests
8. Continuous Feedback and Assessment

Module-1

Introduction to Python Programming

- **Python Basics:** Variables, data types, and basic operators.
- **Control Structures:** If-else conditions, loops (for, while).
- **Basic Input/Output:** Reading from and writing to the console.

Module-2

Data Structures and Collections

- **Lists and Tuples:** Creating and manipulating lists and tuples.
- **Dictionaries and Sets:** Using dictionaries for key-value pairs, and sets for unique elements.
- **List Comprehensions:** Efficiently creating and modifying lists.

Module-3

Functions and Modular Programming

- **Functions:** Defining and calling functions, parameters, and return values.
- **Lambda Functions:** Anonymous functions for compact code.
- **Modules:** Importing and using Python standard libraries.

Module-4

File Handling and Exception Handling

- **Reading and Writing Files:** Handling text and binary files.
- **Exception Handling:** Try-except blocks to manage errors gracefully.
- **Context Managers:** Using `with` statements for file management.

Module-5

Introduction to Libraries for Engineering Applications

- **NumPy:** Arrays, mathematical operations, and linear algebra.
- **Matplotlib:** Basic plotting and visualization for engineering data.
- **Integration with Mechanical Systems:** Simple Python applications to solve engineering problems.

Course outcome (Course Skill Set)

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

1. Write and execute simple Python programs.
2. Implement control structures (e.g., loops, conditionals) and data structures (e.g., lists, dictionaries).
3. Create and call functions to modularize and reuse code.
4. Handle errors and exceptions to ensure program stability.
5. Use libraries such as NumPy and Matplotlib for basic engineering calculations and data visualization.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). The student is declared as a pass in the course if he/she secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous internal Examination (CIE)

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examinations (SEE)

SEE paper shall be set for 50 questions, each of the 01 marks. The pattern of the question paper is MCQ (multiple choice questions). The time allotted for SEE is **01 hour.** The student has to secure a minimum of 35% of the maximum marks meant for SEE.

Suggested Learning Resources:

Books

1. **"Automate the Boring Stuff with Python"** by Al Sweigart
2. **"Python Crash Course"** by Eric Matthes
3. **"Learning Python"** by Mark Lutz
4. **"Python for Data Analysis"** by Wes McKinney
5. **"Python Programming: An Introduction to Computer Science"** by John Zelle

Web links and Video Lectures (e-Resources):

1. **Python Official Documentation:**https://docs.python.org/3/
2. **W3Schools Python Tutorial:** https://www.w3schools.com/python/
3. **Python for Everybody (Coursera):**https://www.coursera.org/specializations/python
4. **NumPy Documentation:** https://numpy.org/doc/stable/
5. **Matplotlib Documentation:** https://matplotlib.org/stable/contents.html

	Activity Based Learning (Suggested Activities in Class)/ Practical Based learning 1. **Interactive Online Coding Platforms:** Encourage students to practice coding through interactive platforms like **Replit**, **Jupyter Notebooks**, or **Google Colab** where they can run Python code directly in their browsers. 2. **Project-Based Learning:** Assign small projects where students can apply the concepts learned in the modules. Example projects could include writing a Python script to calculate the area of mechanical components, plotting data from experiments, or solving simple mathematical problems related to mechanical engineering. 3. **Online Tutorials and Video Resources:** Provide links to YouTube channels or online courses that explain the course concepts in depth, such as **Corey Schafer's Python tutorials** or the **Python for Everybody** Coursera series.

3D Printing and Robotic Simulation Programming		Semester	02
Course Code	MMTP258C	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:0:0:2	SEE Marks	50
Total Hours of Pedagogy	15	Total Marks	100
Credits	01	Exam Hours	1 Hour
Examination type (SEE)	MCQ		

Course objectives:

1. To introduce the core concepts of additive manufacturing and robotic simulation programming.
2. To understand the processes, materials, and applications of 3D printing.
3. To explore the fundamentals of robotic simulation for virtual task planning.
4. To analyze the integration of additive manufacturing and robotics for advanced applications.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Hands-On Coding Assignments
2. Lab Sessions
3. Project-Based Learning
4. Interactive Demonstrations
5. Comparative Analysis
6. Visualizations
7. Regular Quizzes and Tests
8. Continuous Feedback and Assessment

Module-1

Introduction to Additive Manufacturing : Historical Development and Classification of Additive Manufacturing Processes, Process Chain: CAD Model, Slicing, Printing, and Post-Processing, Overview of 3D Printing Technologies: FDM, SLA, SLS, DMLS, Materials for Additive Manufacturing: Polymers, Metals, Ceramics, and Composites, Applications in Aerospace, Healthcare, and Automotive Industries

Module-2

Advanced Additive Manufacturing Processes: Multi-Material and Hybrid Printing Techniques, Lattice Structures and Topology Optimization, Surface Quality, Accuracy, and Post-Processing Methods, Economic and Environmental Considerations, Case Studies of Additive Manufacturing Applications.

Module-3

Fundamentals of Robotic Simulation: Introduction to Industrial Robotics: Kinematics and Dynamics, Basics of Robot Programming and Task Planning, Simulation Platforms: RoboDK, MSC Adams, MATLAB Simulink, Virtual Model Creation and Path Planning, Simulation of Robotic Operations: Assembly, Welding, and Inspection.

Module-4

Multi-Body Simulation and System Analysis : Kinematic and Dynamic Simulation of Multi-Body Systems, Path Optimization and Collision Detection, Virtual Prototyping for Manufacturing and Automation, Failure Prediction through Simulation Analysis, Practical Examples using RoboDK and MSC Adams.

Module-5

Integration and Future Trends: Integration of 3D Printing and Robotic Automation, Digital Twins and Industry 4.0 Applications, Challenges in Process Control and Workflow Synchronization, Emerging Trends: AI in Additive Manufacturing and Robotics, Case Studies and Real-World Implementations.

Course outcome (Course Skill Set)

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

1. Describe the principles, technologies, and workflows of additive manufacturing.
2. Identify appropriate materials and processes for specific 3D printing applications.
3. Simulate robotic operations using virtual programming platforms.
4. Analyze multi-body systems for manufacturing and automation tasks.
5. Evaluate real-world applications of integrated 3D printing and robotics.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). The student is declared as a pass in the course if he/she secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous internal Examination (CIE)

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examinations (SEE)

SEE paper shall be set for 50 questions, each of the 01 marks. The pattern of the question paper is MCQ (multiple choice questions). The time allotted for SEE is **01 hour.** The student has to secure a minimum of 35% of the maximum marks meant for SEE.

Suggested Learning Resources:

Books

1. Gibson, I., Rosen, D. W., & Stucker, B. *Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing*. Springer, 2015.
2. Siciliano, B., & Khatib, O. *Springer Handbook of Robotics*. Springer, 2016.
3. Chua, C. K., & Leong, K. F. *3D Printing and Additive Manufacturing: Principles and Applications*. World Scientific, 2017.
4. Groover, M. P. *Industrial Robotics: Technology, Programming, and Applications*. McGraw Hill, 2012.

Web links and Video Lectures (e-Resources):

	1. NPTEL Course on Additive Manufacturing: https://nptel.ac.in/courses/112/107/112107221/ 2. RoboDK Simulation Tutorials: https://robodk.com/doc/en/Getting-Started.html 3. MIT OpenCourseWare: Additive Manufacturing https://ocw.mit.edu/courses/mechanical-engineering/ 4. Autodesk Fusion 360 Resources: https://www.autodesk.com/products/fusion-360/overview 5. MSC Adams Learning Hub: https://www.mscsoftware.com/msc-adams
	Activity Based Learning (Suggested Activities in Class)/ Practical Based learning ● Collaborative Learning ● Gamification of Learning ● Online Code Repositories

	Numerical Heat Transfer using Spreadsheets		Semester	02
	Course Code	MMTP258D	CIE Marks	50
	Teaching Hours/Week (L:T:P: S)	0:0:0:2	SEE Marks	50
	Total Hours of Pedagogy		Total Marks	100
	Credits	01	Exam Hours	1 Hour
	Examination type (SEE)	**Practical**		

Course Objective:

"To develop practical skills in solving basic heat transfer problems numerically using spreadsheet software such as Microsoft Excel or Google Sheets."

Sl No	Experiment
1	Introduction to Numerical Heat Transfer, Why use spreadsheets
2	Spreadsheet Basics: Formulas, Cell Referencing, Drag-fill, Simple Plots
3	Review of Heat Conduction Equations (1D, steady-state)
4	Discretization: Finite Difference Method (FDM) Basics
5	Solving 1D Steady Heat Conduction using spreadsheets
6	Introduction to Boundary Conditions (Dirichlet, Neumann)
7	Introduction to Transient (unsteady) Heat Conduction
8	Explicit Scheme for 1D Transient Heat Conduction
9	Stability Criteria (Fourier Number concept), Time-step selection
10	Visualization: Temperature profiles, Surface plots using Spreadsheet graphs
11	Case Study 1: Wall Cooling/Heating
12	Case Study 2: Cooling of a metal rod

Course Outcomes:

At the end of the course, students will be able to:

- Apply finite difference methods for simple heat transfer problems.
- Set up and solve 1D steady and transient heat conduction problems using spreadsheets.
- Analyze the effects of boundary and initial conditions numerically.
- Interpret temperature distributions graphically through spreadsheet plotting tools.
- Develop basic templates for iterative numerical solutions without advanced programming.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation (CIE):

CIE marks for the practical course are **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment is to be evaluated for conduction with an observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments are designed by the faculty who is handling the laboratory session and are made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled down to **30 marks** (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct a test of 100 marks after the completion of all the experiments listed in the syllabus.
- In a test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- The marks scored shall be scaled down to **20 marks** (40% of the maximum marks).

The Sum of scaled-down marks scored in the report write-up/journal and marks of a test is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

- SEE marks for the practical course are 50 Marks.
- **SEE shall be conducted by the two examiners. One from the same institute as an internal examiner and another from a different institute as an external examiner, appointed by the university.**
- The examination schedule and names of examiners are informed to the university before the conduction of the examination. These practical examinations are to be conducted between the schedule mentioned in the academic calendar of the University.
- All laboratory experiments are to be included for practical examination.
- (Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.
- Students can pick one question (experiment) from the questions lot prepared by the examiners jointly.
- Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)

Change of experiment is allowed only once and 15% of Marks allotted to the procedure part are to be made zero.

The minimum duration of SEE is 02 hours

Suggested Learning Resources:
Books

- Frank P. Incropera, David P. DeWitt, Theodore L. Bergman, Adrienne S. Lavine, *Fundamentals of Heat and Mass Transfer*, Wiley
- Yunus A. Çengel, *Heat and Mass Transfer: A Practical Approach*, McGraw-Hill
- S. C. Chapra, *Applied Numerical Methods with MATLAB for Engineers and Scientists*, McGraw-Hill (for basic numerical method ideas)
- Additional Online References: Tutorials on Excel-based simulations

Web links and Video Lectures (e-Resources):

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Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Collaborative Learning
- Gamification of Learning
- Online Code Repositories