M. TECH.

THERMAL SCIENCE & ENGINEERING

SYLLABUS
FOR
CREDIT BASED
CURRICULUM

DEPARTMENT OF MECHANICAL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY AGARTALA
Tripura (West), Pin – 799046
INDIA

M.Tech: Thermal Science and Engineering (Syllabus Structure)

Program: M.Tech. Thermal Science and Engineering					
Sl. No.	Course Code	Subject	Credit	Class hours per week	Marks
First Semester					
1		Advanced Mathematics for Engineers	4	3-1-0	100
2		Viscous Fluid Mechanics	4	3-1-0	100
3		Advance Thermodynamics	4	3-1-0	100
4		Conduction and Radiation	4	3-1-0	100
5		Elective – I	4	3-1-0	100
6		Experimental Methods in Thermal Engineering.	2	0-0-3	100
7		Computational Fluid Dynamics Laboratory	2	0-0-3	100
8		Technical Writing and Seminar	1	0-0-2	100
	Total		25	28	800
Second Semester					
1		Convective Heat and Mass Transfer	4	3-1-0	100
2		Elective – II	4	3-1-0	100
3		Elective – III	4	3-1-0	100
4		Elective – IV	4	3-1-0	100
5		Convective Heat and Mass Transfer Laboratory	2	0-0-3	100
6		Lab - Laboratory based on Elective Subjects (E-II/E-III/E-IV)	2	0-0-3	100
7		Project Preliminary	3	0-0-6	100
8		Comprehensive Viva Voce	2	0-0-0	100
	Total		25	28	800
Third Semester					
1		Project and Thesis – 1	10	0-0-0	100
Fourth Semester					
1		Project and Thesis – 2	20	0-0-0	300
	Total Credit		80	Total Marks	2000

Electives (M.Tech. Thermal Science and Engineering)					
Sl. No.	Course Code	Subject	Credit	Class hours per week	Marks
1		Computational Methods in Fluid Flow and Heat Transfer	4	3-1-0	100
2		Design of Thermal System	4	3-1-0	100
3		Two Phase Flow and Heat Transfer	4	3-1-0	100
4		Design of Combustion Engine	4	3-1-0	100
5		Finite Element Methods	4	3-1-0	100
6		Computational Fluid Dynamics	4	3-1-0	100
7		Alternative Fuels and Energy Systems	4	3-1-0	100
8		Compressible flow	4	3-1-0	100
9		Engine Combustion and Emissions	4	3-1-0	100
10		FEM Modeling and Analysis Laboratory	2	0-0-3	100
11		Two Phase Flow and Heat Transfer Laboratory	2	0-0-3	100
12		Computation Methods in Fluid Flow and heat Transfer Lab	2	0-0-3	100

Program Outcomes for M.Tech (Thermal Science and Engineering) Program

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: Student should be able to demonstrate a degree of mastery in the respective specialization of the program above than the requirements of a corresponding bachelor program

PO4: An ability to identify, formulate and solve problems related to thermal science and engineering through analytical, numerical and experimental techniques.

PO5: Student should be able to apprehend and understand the impact of a chosen thermal related problems and solutions in the context of scientific, social, environmental and economic progress

PO6: An ability to demonstrate and practice sustainability, ethics and management principle in the related engineering field

PSO	Program specific outcomes
PSO1	Specification, fabrication, testing, operation or documentation of basic mechanical systems/processes
PSO 2	Analysis, design, development and implementation of more advanced mechanical systems or processes.

FIRST SEMESTER
ADVANCED MATHEMATICS FOR ENGINEERS

Semester: 1st M. Tech.	Credit: 4					
Course Name: Advanced Mathematics for Engineers	**L**	**T**	**P**	3	1	0

Course Objectives:

1) Solving optimization problems, boundary value problems viz. Heat equation, Wave equation & mathematical modeling which are very useful in engineering field.
2) Simulation modeling is used to solve mathematical models based on probabilistic and statistical methods related to real-world problems safely and efficiently
3) To solve homogeneous, non-homogeneous linear equation & numerical solution of partial differential equation.

Syllabus Content

Module 1:

Calculus of Variations: Variation and its properties, Euler's equation, Conditional extreme, Isoperimetric problems, Functional dependent on first and higher order derivatives, Functional dependent on functions of several independent variables, Some applications- Direct methods Ritz and Kantorovich methods, Eulers finite difference method.

Module 2:

Laplace Transform & Fourier Transform: Applications of fourier transform in solving initial & boundary value problems. Laplace equation, Heat equation & wave equation.

Module 3:

Hankel's Transform: Eliminating properties of Hankel transform, Hankel inversion, and transform theorem, Hankel transform of derivatives of functions, Parsevel's theorem.

Module 4:

Simulation: Types, case studies in various fields using simulation technique, simulation software's used, use of mathematical models based on probabilistic and statistical methods.

Module 5:

Partial Differential Equation: Formation of PDE, Solution of PDE, Equation solvable by direct integration, linear equation of first order, Non-linear equation of first order, Charpit's method, Homogeneous linear equations with constant co-efficient, Non-homogeneous linear equation, Non-linear equation of second order.

Module 6:

Solution of parabolic & Hyperbolic equations: Implicit & Explicit schemes, ADI methods, Nonlinear parabolic equations – iteration method, Solution of elliptic equation-Jaccobi method, Gauss Seidel & SOR method, Ricardson method, RKF4 method, Galarkin's method.

Module 7:
Introduction to finite element method & scope

Text Books:

i) Calculus of Variations with Applications, Gupta A.S, Prentice Hall India Learning Private Limited
ii) Stochastic Modeling: Analysis & Simulation, Barry L Nelson, Dover Books on Mathematics
iii) Advanced Differential Equations, M.D. Raisinghania, S Chand Publishing
iv) Numerical Analysis, S.A.Mollah, Books & Allied Ltd

Reference Books:

i) Advanced Engineering Mathematics, E. Kreyszig, John Wiley & Sons
ii) Numerical Methods in Engineering and Science, B. S. Grewal, Khanna Publishers
iii) Advanced Engineering Mathematics, H. K. Dass, S. Chand Publishing

Course Outcomes

CO-No.	Course Outcome	Module Covered
1	Students will be able to analyze and solve optimization problems in Engineering using different techniques.	**1**
2	Students will be able to solve the boundary value problems viz. Heat equation, wave equation	**2, 3**
3	Students will learn to analyze and compute mathematical models based on probabilistic and statistical methods	**4, 7**
4	Student can be able to solve homogeneous, non-homogeneous linear equations arising in Engineering problems	**5**
5	Student can be able to solve the problems of partial differential equation using numerical techniques	**6, 7**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	-	2	3	2	-	-	-
CO-2	3	1	1	3	2	-	-	-
CO-3	3	2	2	3	2	-	-	-
CO-4	2	-	1	3	2	-	-	-
CO-5	1	-	1	3	2	-	-	-

VISCOUS FLUID MECHANICS

Semester: 1st	Credit: 4					
Course Name: Viscous Fluid Mechanics	**L**	**T**	**P**	3	1	0

Course Objectives:

The course is intended to

1. Establish an understanding of the fundamental concepts of fluid mechanics.
2. Understand and apply the potential flow equations to basic flows.
3. Demonstrate and apply the differential equations of fluid mechanics including
1. the impact of assumptions made in the analysis.
4. Understand the boundary layer concepts with respect to fluid flow
5. Understand and apply the compressible flow equations.

Syllabus Content

Module1:

Review of Basic concepts- Reynolds's transport theorem, Fluid kinematics – Physical Conservation laws – Integral and differential formulations, stress-deformation relation, vector and tensor calculus, vorticity and circulation, Potential flow, derivation of Navier-Stokes equations.

Module2:

Flow analysis: Navier-Stokes and energy equations, Exact solutions: Couette flow, Hagen-Poiseuille flow, Stoke's problems; Dimensionless forms and dimensionless numbers – Solution of Navier-Stokes equations.

Module3:

Boundary layer theory, Boundary layer thickness, Prandtl's equations, solution-skin Friction coefficient, Two-dimensional boundary layer, Blassius solution, Kármán-Pohlhausen method,

Module4:

Flow over bluff bodies, effect of pressure gradient, Flow separation and control.

Module5:

Flow instability: concept of small-perturbations, linearized stability of parallel viscous flows, different flow instabilities.

Module6:

Turbulent flows, RANS model, Reynolds stress tensor, Reynolds equation – Prandtl and von Karman hypothesis, Universal velocity Profile near a wall- flow through pipes, fully developed Turbulent flow through pipes and channel.

Text Books:

i. Fluid Mechanics, Pijush Kundu and Ira Cohen, 2nd edition, Academic press, An imprint of Elsevier Science.
ii. Fluid Mechanics, Yunus A. CENGAL, 2nd edition. McGraw-Hill, 2010

References:

i. Currie, LG., Fundamental Mechanics of Fluids, 4th ed., CRC Press, 2012.
ii. White, P.M., Viscous Fluid Flow, 2nd ed., McGraw-Hill, 1991.
iii. Ockendon, H. and Ockendon, J., Viscous Flow, Cambridge Uni. Press, 1995.

Course Outcomes

At the end of the course, Students will be able to

CO-No.	Course Outcome	Module Covered
1	Formulate and solve basic problems of fluid mechanics	**1,2**
2	To identify, formulate and analyze specific fluid mechanics problems using the concepts of NS and exact solution.	**2, 3**
3	To solve and analyze practical problems suing appropriate approximations.	**3,4**
4	To understand and apply the concept of flow instabilities	**5**
5	Apply the concepts of Turbulent flow analysis in important Engineering flow scenarios.	**5,6**
6.	Facilitate students to learn advanced principles of fluid mechanics for broader application to Mechanical Engineering especially Thermo-Fluid domain related projects	**2 to 6**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	2	2	3	3	2	2	2	2
CO-2	2	2	3	2	3	3	3	2
CO-3	2	3	3	3	2	2	3	2
CO-4	3	3	3	2	2	1	3	3
CO-5	3	2	3	3	3	1	2	2
CO-6	2	3	3	2	3	2	2	3

ADVANCE THERMODYNAMICS

Semester: 1st	Credit: 4					
Course Name: Advance Thermodynamics	**L**	**T**	**P**	3	1	0

Course Objectives:

1) This course aims to provide a good platform to mechanical engineering students to understand, model and appreciate concept of dynamics involved in thermal energy transformation.

2) To prepare them to carry out experimental investigation and analysis at later stages of graduation.

Syllabus Content

Module 1:

Review of Thermodynamics: Introduction, Significance and limitations, System and Boundary, Simple System, Constraints and Restraints, Composite System, Phase, Homogeneous, Pure Substance, Amount of Matter and Avogadro Number, Mixture, Property, State, Equation of State, Standard Temperature and Pressure, Partial Pressure, Process, Vapor–Liquid Phase Equilibrium Mathematical Background: Explicit and Implicit Functions and Total Differentiation, Exact (Perfect) and Inexact (Imperfect) Differentials, Mathematical Criteria for an Exact Differential.Relevance to Thermodynamics, Work and Heat, Integral over a Closed Path (Thermodynamic Cycle),Homogeneous Functions, Relevance of Homogeneous Functions to Thermodynamics, LaGrange Multipliers, Composite Function

Overview of Microscopic/Nano-thermodynamics: Matter, Intermolecular Forces and Potential Energy, Collision Number, Mean Free Path, and Molecular Velocity, Collision Number and Mean Free Path, Maxwellian Distribution of Molecular Velocity, Average, Root Mean Square (RMS), and Most Probable Speeds. Thermal and Internal Energy: Monatomic Gas, Diatomic Gas, Triatomic and Polyatomic Gases, Temperature, Pressure: Relation between Pressure and Temperature, Gas, Liquid, and Solid, Work, Heat Transfer and Thermal Equilibrium, Chemical Potential: Multi-component into Multi-component, Single Component into Multi-component, Boiling/Phase Equilibrium: Single Component Fluid, Multiple Components, Entropy: Overview, Energy Levels or Quantum Numbers, Macro- and Microstates and Entropy, Entropy of a Solid, a Liquid and a Gas, Relation between Entropy, Energy and Volume, Properties in Mixtures: Partial Molal Property, Stokes and Gauss Theorems: Gauss–Ostrogradskii Divergence Theorem, The Leibnitz Formula.

Module 2:

Laws of thermodynamics: Objectives; First Law for a Closed System Energy Conservation Equation in Various Forms: Elemental Process, Integrated Form, Uncoupled (Conservative) and Coupled (Nonconservative) Systems Adiabatic Form and Caratheodary Axiom I, Cyclical Form and Poincare Theorem First Law in Rate Form, Quasi-Equilibrium (QE) and Nonquasi-Equilibrium (NQE) Processes, Enthalpy and First Law, Adiabatic Reversible Process for Ideal Gas with Constant Specific Heats. First Law for an Open System: Conservation of Mass, Conservation of Energy for a Simple Open System. Conservation of Energy for Complex Open System, Applications of First Law for an Open System, Integral and Differential Forms of Conservation Equations. Second Law of Thermodynamics and Entropy, Consequences of the Second Law,Entropy Balance Equation for a Closed System, Irreversibility Entropy

Measurements and Evaluation. Local and Global Equilibrium Entropy: Energy Relation for Single Component Incompressible Fluids, Third Law

Availability: Optimum Work and Irreversibility in a Closed System Availability or Exergy Analyses for a Closed System, Generalized Availability Analysis ,Availability/Exergetic Efficiency, Chemical Availability, Integral and Differential Forms of Availability Balance; Transient system/Flow Analysis Exergy analysis and exergy balance equations for open systems and thermodynamic cycles

Module: 3:

Thermodynamic Properties of Pure Fluids: Introduction, James Clark Maxwell, 1831–1879 Relations, Generalized Relations Evaluation of Thermodynamic Properties Pitzer Effect Kesler Equation of State (KES) and Kesler Tables Fugacity. Vapor/Liquid Equilibrium Curve Throttling Processes

Thermodynamic Properties of Mixtures: Introduction, Generalized Relations and Partial and Mixture Molal Properties. Partial Molal Property and Characteristics Useful Relations for Partial Molal Properties Ideal Gas Mixture Molal Properties using the Equations of State

Module 4:

Stabilityand Equilibrium: Introduction, Mathematical Criterion for Stability Perturbation of Energy Perturbation with Energy and Volume System with Specified Values of S, V, and m System with Specified Values of T, V, and m System with Specified Values of T, P, and m Application to Boiling and Condensation Entropy Generation during Irreversible Transformation Spinodal Curves

Chemically Reacting Systems**:** Introduction, Chemical Reactions and Combustion Thermochemistry First Law Analyses for Chemically Reacting Systems Combustion Analyses in the Case of Nonideal Behavior Second Law Analysis of Chemically Reacting Systems Mass Conservation and Mole Balance Equations

Module 5:

Thermodynamics and Biological Systems: Introduction,Biomass Processing Food and Nutrients: Thermo-chemical Properties of Nutrients, Metabolism of Nutrients Mixture of CH, F, and P, Human Body. Metabolism, BMR Estimation Thermo-chemistry of Metabolism in BS Heat Transfer Analysis from the Body Body Temperature and Warm and Cold Blooded Animals Second Law and Entropy Generation in BS Entropy Generation through Chemical Reactions Life Span and Entropy Allometry

Text Books:

i) Beattie, J. A., and Oppenheim, I., Principle of Thermodynamics, New York: John Wiley, 1979.
ii) Annamalai, K., Puri, I. K., and Jog, Advanced Thermodynamics Engineering Biological Thermodynamics, Taylor& Francis, Boca Raton, FL, Aug. 2009.

Reference Books:

i) Callen, H. B. Thermodynamics: An Introduction to the Physical Theories of Equilibrium Thermostatistics and Irreversible Thermodynamics, New York: John Wiley, 1960
ii) Cengel, Y. A., and M. A. Boles, Thermodynamics, an Engineering Approach, 3rd \ed., New York: McGraw-Hill Book Co., 1998.

iii) Gyftopoulos, E. P., and G. P. Beretta, Thermodynamics: Foundations and Applications, Mineola, NY: Dover,1991, 2005.

iv) Bejan, A., “Advanced Engineering Thermodynamics”, 3rd Ed., John Wiley & Sons. 2006

Course Outcomes

CO-No.	Course Outcome	Module Covered
1	Formulate and manipulate the thermodynamic treatment of arbitrary processes.	**1,2**
2	To identify, formulate, manipulate and analyze specific Mechanical Engineering problems using fundamental concepts.	**2.3**
3	To instill upon to envisage appropriate approximations for practical problem solving.	**3,4**
4	To investigate the effectiveness of energy conversion process in mechanical power generation for the benefit of mankind.	**4,5**
5	Understand the implications of approximations on the efficiency and accuracy of the solution.	**3,4,5**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	2	2	3	3	2	2	2	1
CO-2	2	2	3	2	3	3	2	2
CO-3	2	3	3	3	2	2	2	1
CO-4	3	3	3	2	2	1	2	1
CO-5	3	2	3	3	3	1	2	2

CONDUCTION AND RADIATION

Semester:	Credit: 4					
Course Name: Conduction and Radiation	**L**	**T**	**P**	3	1	0

Course Objectives:

1) This course aims to provide a good platform to the students to understand, model and design systems involving conduction and radiation energy transport.
2) Student will be able to design and conduct experiments, as well as to organize, analyze and interpret data to produce meaningful conclusions and recommendations.

Syllabus Content

Module1:

Introduction to conduction heat transfer;Derivation of heat conduction equation, analysis of basic 1D and 2D conduction.

Module2:

Multi-dimensional steady and unsteady problems in Cartesian and Cylindrical coordinates.

Module3:

Semi-infinite solids. Duhamel's Superposition Integral. Solidification and Melting. Inverse heat conduction.

Module4:

Physical mechanism. Laws of thermal radiation. Radiation properties of surfaces. View factors for diffuse radiation.

Module5:

Radiation exchange in black and diffuse gray enclosures. Radiation effects in temperature measurement. Enclosure theory for surfaces with wall temperatures that are continuous functions of space. Spectrally diffuse enclosure surfaces.

Module6:

Approximate solution methods for one-dimensional media, The optically thin and optically thick approximations. Radiation in participating media, Gas radiation. Combined Conduction and Radiation.

Text and References:

i) Fundamentals of Heat and Mass Transfer by Frank P. Incropera, David P. DeWitt, Theodore L. Bergman, Adrienne S. Lavine (John Wiley and Sons)
ii) Heat and Mass Transfer byYunus Cengel, Afshin Ghajar(McGraw-Hill)
iii) Heat Conduction byLatif M Jiji (Springer)
iv) Radiative Heat Transfer by Michael F. Modest (Academic Press)

v) Kreith, F. and Bohn, M. S., "Principles of Heat Transfer", 6th Ed., Thomson Learning. 2007

vi) Ozisik, M. N., "Heat Conduction", 2nd Ed., John Wiley & Sons. 1993

vii) Siegel, R., and Howell, J. K., "Thermal Radiation Heat Transfer", Taylor & Francis. 2002.

Course Outcomes

At the end of the course, Students will be able to

CO-No.	Course Outcome	Module Covered
1	Student will be able to demonstrate and apply in basic governing equations in design and operation of conduction and radiation thermal systems	**1,2,4**
2	Student will be able to investigate and design conduction heat transfer systems or components or process of higher dimensional aspects and complexity	**2,3**
3	Student will be able to design thermal systems or components or process considering the appropriate approximation and boundary conditions.	**3,4**
4	Student will be able to analyze, approximate and apply the concept of radiation in different surfaces and enclosures.	**4,5**
5	Student will be able to work individually and test basic thermal systems with Combined Conduction and Radiation problems.	**5,6**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	3	3	2	2	3	2
CO-2	2	2	3	2	3	3	3	3
CO-3	3	3	2	3	2	1	3	2
CO-4	3	2	3	2	2	1	2	3
CO-5	3	3	3	3	3	3	3	2

EXPERIMENTAL METHODS IN THERMAL ENGINEERING LABORATORY

<table>
<tr><td>Semester: 1st</td><td colspan="6">Credit: 2</td></tr>
<tr><td>Course Name: Experimental Methods in Thermal Engineering Laboratory</td><td>L</td><td>T</td><td>P</td><td>0</td><td>0</td><td>3</td></tr>
</table>

Course Objectives:

1) To demonstrate and apply theory and experimentation in Thermal Sc Engineering.
2) To inculcate and train about error and accuracy in measuring system, types of inputs, analog and digital signals, standards, calibration and uncertainty, measurement system.
3) To orient students for analysis of experimental data, error analysis, uncertainty analysis, data reduction techniques, statistical analysis of data, probability distributions and curve fitting.
4) To give practical exposure to students related to thermometry - heat flux measurement – thermos-physical properties.
5) To give exposure related to safety and standards in a work place.

List of Experiments

Exp1: Introduction of different sensor and transducer in thermal science and engineering applications.

Exp2: Error estimation and statistical applications in thermal measurements.

Exp3: Study the heat transfer through composite walls

Exp4: Study the heat transfer through pin-fin apparatus

Exp5: Study the Stefan Boltzmann apparatus

Exp6: Study shell and tube heat exchanger

Exp7: Study the critical heat flux apparatus

Exp8: Study the unsteady state heat transfer apparatus

Exp9: Study the mini air conditioning tutor apparatus

Exp10: Study of CI Engine System

Exp11: Study of SI Engine System

Exp12: Study of mini gas turbine

Prerequisite knowledge required on:

1) Basics concepts of measurement
2) Analysis and synthesis of experimental data
3) Basics of thermal measurements- such as pressure, temperature and flow
4) Basics of mechanical measurements- such as force, torque and strain
5) Basics of motion and vibration
6) Air pollution sampling and design

Course Outcomes:

At the end of the course, Students will be able to

CO-No.	Course Outcome	Experiment Covered
1	Gain confidence in executing experimental investigations & data analysis	1 to 11
2	Understand and apply knowledge on modern engineering experimentation, including experiment design, calibration, data acquisition, analysis, and interpretation	3, 5 & 6
3	Able to conduct experiments using real-world transducers / data acquisition system with specifications on resolution and accuracy.	8 & 11
4	Analyze the data using signal processing technique and uncertainty analysis for scientific and meaningful representation.	9, 10 & 11
5	Able to develop experimental setup/Numerical codeduring final year thesis work.	1 to 11

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	3	3	3	2	3	2	3
CO-2	3	3	3	2	1	3	2	3
CO-3	3	3	3	3	2	1	3	2
CO-4	3	3	3	2	2	1	2	3
CO-5	3	3	3	3	1	1	3	3

COMPUTATIONAL FLUID DYNAMICS LABORATORY

Semester: 1st	Credit: 2					
Course Name: Computational Fluid Dynamics Laboratory	**L**	**T**	**P**	0	0	3

Course Objectives:

1) To train and apply the fundamentals knowledge and concepts (learned from fluid courses) for a real life numerical simulation problems.
2) To apply the CFD theory along with boundary conditions in a numerical simulation.
3) Provide exposure of comparative study of different numerical modeling and scheme.
4) To familiarize students with the necessary skills to use available open source and commercial CFD packages.
5) To carry out term project in the area of Computational Fluid Dynamics.

List of Experiments

Exp1: Introduction to SCI-Lab

Exp2: Matrices summations, multiplication and inverse matrices using SCI-Lab

Exp 3: Determinant of Matrices using SCI-Lab

Exp 4: Solution of linear set of equations by Gauss Jordan, Gauss Seidel and Gauss elimination.

Exp 5: Lower and upper decomposition of Matrices

Exp 6: One dimensional steady and unsteady state heat analysis of fin

Exp 7: Two dimensional Laplace equation solution of a heat transfer

Exp 8: Two dimensional unsteady heat analysis of a slab solution

Exp9: To develop a code to find Solution of PCM heat exchanger

Exp 10: Term paper submission

Course Outcomes:

At the end of the course, Students will be able to

CO-No.	Course Outcome	Experiment Covered
1	Able to gain better concept, more clear understanding and firm grasp of the basic principles in CFD with computational fluid flow engineering and sciences	1 to 10
2	Able to get better understanding about the underlying physics behind the phenomena related to fluid flow	1 to 5
3	Developed creative thinking and a deeper understanding and intuitive feel for fluid engineering and sciences	6 to 9
4	Developed necessary skills to bridge the gap between knowledge and the confidence to properly apply knowledge on the broad application area of fluid flow engineering	6 to 9
5	Build up the skills in the actual implementation of CFD methods (e.g. boundary conditions, turbulence modelling etc.) with their own codes	9

CO-PO Mapping (Rate: scale of 1to3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	3	3	3	2	2	2	2
CO-2	3	3	3	2	1	2	2	3
CO-3	3	3	3	3	2	2	3	3
CO-4	3	3	3	2	1	1	3	2
CO-5	3	3	3	3	1	1	2	3

TECHNICAL WRITING AND SEMINAR

Semester: 1st	Credit: 1					
Course Name: Technical Writing and seminar	**L**	**T**	**P**	0	0	2

Course Objectives:

1) To acquire the information from different sources for preparing seminar and research reports
2) To develop the presentation and participation skills.

Syllabus Content

Module 1:

Each student shall prepare a seminar presentation on any topic of his/her interest. However, the topic must be someway related to the core/elective courses being credited by him/her during the first semester. He/ She shall get the paper approved by the faculty advisor and present it in the class in the presence Faculty in charge. Every student shell participates in the seminar. Grade will be awarded on the basis of the quality of the paper, his/her presentation and participation in the seminar.

Module 2:

Finding problems and to be reported of any machine components. Finding out the solution of those problems.

Module 3:

Writing a report on performance of a machine component for a particular duration.

Course Outcomes

CO-No.	Course Outcome	Module Covered
1	Summarizes information from different sources for preparation of reports and PPT.	**1**
2	Evaluate work in team and develop short term project	**2&3**
3	Solve various social problem taking various social relevant activity using core knowledge.	**2**
4	Investigate and formulate the research study article	**1&2**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1		3					3	1
CO-2		2	3				2	1
CO-3			3				2	3
CO-4	3	3					2	1

SECOND SEMESTER
CONVECTIVE HEAT AND MASS TRANSFER

Semester: 2^{nd}	Credit: 4					
Course Name: Convective Heat and Mass Transfer	**L**	**T**	**P**	3	1	0

Course Objectives:

1) This course aims to provide a good platform to the students to understand, model and design systems involving convective energy and mass transport.
2) Student will be able to model, design and conduct assessment, as well as to organize, analyze and interpret data to produce meaningful conclusions and recommendations on convective energy and mass transport.

Syllabus Content

Module 1:

Convective heat transfers and its applications; Mass, momentum, energy equations, Forced, free and mixed convection; internal and external flow; heat transfer coefficient and its physical significance; dimensional analysis in convective heat transfer.

Module 2:

Boundary layer equations; energy equation for flow over flat plate; similarity solution for flow over a flat plate having various boundary conditions and Prandtl numbers; Scale analysis; Approximate method; Viscous dissipation effect of laminar boundary layer. Developing and developed flow and heat transfer in a duct and circular pipe having various boundary conditions.

Module 3:

Natural/Free convection, Boussinesq approximations; Similarity solution for flow over a flat plate; Scale analysis; Approximate method; Mixed convection and the corresponding governing equations.

Module 4:

Active and passive methods; State of flow and flow structure affecting heat transfer; Flow design of heat exchangers, Pool boiling regimes and the boiling curve; heat transfer correlations in pool boiling; flow boiling and its regimes, Condensation from vertical flat plate, multiple horizontal and vertical tubes.

Module 5:

Characteristics of turbulent flow and heat transfer; Reynolds stress N-S and energy equations, eddy viscosity based turbulence models, turbulent flow over flat plate (external), turbulent flow in pipe.

Module 6:

Mass transfer, Various non-dimensional numbers and their analogy to those of heat transfer; Analogy friction, heat transfer and mass transfer coefficients; species equations; Examples of simultaneous heat and mass transfer.

Text and Reference Books:

i. Introduction to Convective Heat Transfer Analysis by Patrick H. Oosthuizen and David Laylor (McGraw-Hill)
ii. Convective Heat and Mass Transfer by Kays, Crawford and Weigand (4th Edition, McGraw-Hill)
iii. Convective Heat Transfer by L. C. Burmeister (John Wiley and Sons)
iv. Convective Heat Transfer by M Favre-Marinet and S Tardu (John Wiley and Sons)
v. Principles of Convective Heat Transfer by Massoud Kaviany (2nd Edition, Springer)
vi. Convective Heat Transfer by I. Pop and D. B. Ingham (Pergamon)
vii. Convective Heat Transfer by Adrian Bejan (John Wiley and Sons)
viii. Heat Convection by Latif M Jiji (Springer)
ix. Viscous Fluid Flow by Frank M White (McGraw-Hill)
x. Boundary Layer Theory by H Sctllichting (McGraw-Hill)

Course Outcomes

At the end of the course, Students will be able to

CO-No.	Course Outcome	Module Covered
1	Student will be able to demonstrate and apply in basic governing equations in design and operation of convective and mass transfer systems	**1,2,4,6**
2	Student will be able to investigate and design convective heat transfer systems or components or process of higher dimensional aspects and complexity	**2,3,4**
3	Student will be able to design thermal systems or components or process considering the appropriate approximation and boundary conditions.	**3,4**
4	Student will be able to analyze, approximate and apply the concept of turbulent flow.	**5**
5	Student will be able to work individually and test advanced thermal systems with Combined effect of Convection and mass problems.	**5,6**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	3	3	2	2	2	3
CO-2	2	2	3	2	3	3	1	3
CO-3	2	3	2	3	2	2	2	3
CO-4	3	2	3	2	2	2	3	2
CO-5	3	3	3	3	2	2	2	3

CONVECTIVE HEAT AND MASS TRANSFER LAB

Semester:	Credit: 2				
Course Name: Convective Heat and Mass Transfer Lab	**L**	**T**	**P**	0	0	3

Course Objectives:

1) To introduce students theory and experimentation in engineering - problem solving approaches, types of engineering experiments, computer simulation and physical experimentation.
2) To introduce students generalized measuring system, types of inputs, analog and digital signals, standards, calibration and uncertainty, measurement system - performance characteristics;
3) To orient students for analysis of experimental data, error analysis, uncertainty analysis, data reduction techniques, statistical analysis of data, probability distributions and curve fitting.
4) To give students exposure to thermometry - heat transfer coefficient measurement – thermos-physical properties - measurement of derived quantities - torque, power, radiation and surface properties and experimentation.
5) To give students exposure to measurement of pressure, flow velocity, measurement of temperature, optical methods of measurements, hot wire anemometry and theoretical aspects of wind tunnels and flow visualization, hot film anemometry, laser Doppler anemometer, instrumentation in two-phase flows, particle image velocimetry technique.

List of Experiments

Exp1: Study heat transfer in a flow boiling.

Exp2: Study temperature measurement using Arduino card.

Exp3: Study pressure drop measurement using Arduino card.

Exp4: Study of Boiling heat transfer coefficient.

Exp5: Study of Condensation heat transfer coefficient

Exp6: Study of Meteorological data for various applications.

Exp7: Study of heat transfer during air cooling in wind turbine.

Exp8: TERM paper preparation and seminar work.

Course Outcomes

At the end of course, students will be able to

CO-No.	Course Outcome	Experiment Covered
1	Student will be able to demonstrate and apply in basic governing equations in design and operation of convective and mass transfer systems	**1,2,4,6**
2	Student will be able to investigate and design convective heat transfer systems or components or process of higher dimensional aspects and complexity	**2,3,4**
3	Student will be able to design thermal systems or components or process considering the appropriate approximation and boundary conditions.	**3,4**

4	Student will be able to analyze, approximate and apply the concept of turbulent flow.	**5**
5	Student will be able to work individually and test advanced thermal systems with Combined effect of Convection and mass problems.	**5,6**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	3	3	2	2	3	2
CO-2	2	2	3	2	3	3	1	3
CO-3	2	3	2	3	2	2	2	3
CO-4	3	2	3	2	2	2	3	2
CO-5	3	3	3	3	2	2	2	3

COMPREHENSIVE VIVA

Semester: 2nd	Credit: 2					
Course Name: Comprehensive Viva	**L**	**T**	**P**	0	0	0

Course Objectives:

1) To assess the overall knowledge of the student in the field of Thermal Science and Engineering acquired over one year of study in post graduate program.

Course Outcomes

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

CO-No.	Course Outcome
1	Comprehend any given problem / concept related to thermal science and engineering domain.
2	Recall, recognize, visualize, demonstrate, criticize and appraise the concepts related to thermal science and engineering domain.

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	**3**		**3**				**3**	**2**
CO-2	**3**		**3**				**1**	**3**

PROJECT PRELIMINARY

Semester: 2nd	Credit: 3					
Course Name: Project Preliminary	**L**	**T**	**P**	0	0	6

Course Objectives:

1) To provide the opportunities to the student to demonstrate and develop concept/project in the respective Engineering Domain
2) To enable a student to work in cutting edge research problems in harmony.
3) To inculcate the practice of carrying research with ethics and safety.

Course Outcomes

CO-No.	Course Outcome
1	Undergo literature survey in the chosen field of research
2	Approach and identify a research problem and able to analyze the scope of research
3	Develop a research methodology to proceed with the research
4	Summarize and Present a technical presentation with proper reference

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	-	-	3				3	1
CO-2	3	-	3				3	2
CO-3	3	3	3				2	3
CO-4	-	3	3				3	2

THIRD SEMESTER

PROJECT AND THESIS – I

Semester: 3rd	Credit: 10					
Course Name: Project and Thesis – I	**L**	**T**	**P**	0	0	0

Course Objectives:

1) To provide the opportunities to the student to demonstrate and develop concept/project in the respective Engineering Domain
2) To enable a student to work in cutting edge research problems in harmony.
3) To inculcate the practice of carrying research with ethics and safety.

Course Outcomes

CO-No.	Course Outcome
1	Intensive literature survey and identify the research problems related to Material Science and Engineering.
2	Communicate and discuss research ideas
3	Develop a systematic model/approach to analyze and solve the research problems.
4	Outline the past, present and expected outcome based on systematic survey.
5	Conduct preliminary experiments / theoretical evaluation to certain extent.
6	Summarize their survey, research problem identification, approach, ,expected outcome and attained results with interpretation by means of oral presentation and written reports

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	-	3				3	1
CO-2	3	2	3				3	2
CO-3	3		3				2	3
CO-4	3	3	3				3	2
CO-5	3		3				3	2
CO-6	3	3	3				3	2

FOURTH SEMESTER

PROJECT AND THESIS – II

Semester: 4th				Credit: 20		
Course Name: Project and Thesis – II	**L**	**T**	**P**	0	0	0

Course Objectives:

1) To provide the opportunities to the student to demonstrate and develop concept/project in the respective Engineering Domain
2) To enable a student to work in cutting edge research problems in harmony.
3) To inculcate the practice of carrying research with ethics and safety.

Course Outcomes

CO-No.	Course Outcome
1	Survey, approach, identify and demonstrate the research / industrial problems using various available modern tools and techniques
2	Develop and validate a systematic model/processto analyze and solve the research problems.
3	Outline the past, present and expected performance / outcome of a material / product / process / model / system(s) in Engineering domain in confirmation to the standard of safety and environmental, economicand ethical yardstick.
4	Conduct experiments and theoretical evaluation extensively
5	Analyze, summarize, inferbased on extensive research and communicate their chosen domain problems and result optimistically by means of oral presentation and written dissertation reports
6	Present and publish their findings as technical manuscript in technical conference/ indexed research journals ethically.

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	**3**	**2**	**3**				**3**	**1**
CO-2	**3**	**2**	**3**				**3**	**2**
CO-3	**3**	**3**	**3**				**2**	**3**
CO-4	**3**	**2**	**3**				**3**	**2**
CO-5	**3**	**3**	**3**				**3**	**2**
CO-6	**2**	**3**	**3**				**3**	**2**

LIST OF ELECTIVES

COMPUTATIONAL METHODS IN FLUID FLOW AND HEAT TRANSFER

Semester:	Credit: **4**					
Subject Name: Computational Methods in Fluid Flow and Heat Transfer	L	T	P	**3**	**1**	**0**

Course Objectives:

1) Classification of the basic equations for fluid dynamics and heat transfer.
2) Discretization of transport equations for compressible and incompressible flow.
3) Finite volume methods for heat transfer and fluid flow in one and more dimensions: Diffusion, advection, convection-diffusion, Euler and Navier-Stokes equations.
4) Numerical solution of inviscid flow with modern upwind methods.
5) Numerical solution of the unsteady gas dynamical equations.
6) The SIMPLE and SIMPLER algorithms for the coupling of pressure and velocity for incompressible flow.
7) Steady state and unsteady problems.
8) Solution of algebraic systems of equations.
9) Basics of turbulence modeling and grid generation.
10) Introduction to a computational fluid dynamics (CFD) tool and application to heat and fluid flow.

Course Contents:

Module 1: Preliminaries

Review of Equations Governing Fluid Flow and Heat Transfer, Applied Numerical Methods, Numerical Solutions of Ordinary Differential Equations, Finite Differences, Discretization, Consistency, Stability and Fundamentals of Fluid Flow Modelling.

Module 2: Incompressible Flow and Heat Transfer

Finite Difference applications in heat conduction & convection, Solution of viscousincompressible flows by the stream function - vorticity formulation,

Module 3: Solution of Incompressible Flow:

Incompressible Navier-Stokes equations and algorithms - Basics of grid generation, Central Differencing of the Incompressible Navier-Stokes Equations, The need for a Staggered Grid, The Philosophy of the Pressure Correction Method, The Pressure Correction Formula, The numerical Procedure: The SIMPLE Algorithm, Boundary Conditions for the Pressure Correction Method

Module 4: Finite Volume Method& Finite Element Method

Governing Equations, Regular Finite Volumes, Approximations in the Discretization Technique, Discretization Procedure, Semi Explicit Method, Initial and Boundary Conditions, Implementation Issues, Solution Algorithm, Treatment of Complex Geometry, Application to Fluid Flow and Heat Transfer Problem. Weighted Residual and Variational Formulations, Rayleigh-Ritz Method, Interpolation, Numerical Integration

Module 5: Turbulence and its modeling

Introduction to turbulence, isotropic & anisotropic turbulence, The dynamics of turbulence, Classical idealization of turbulent flows, Structure of vortex dominated flows, Turbulence modeling, the k-€ model, the RNG k- € model and phase-averaged model, Modeling of near wall turbulent flows, Direct numerical simulation, Large eddy simulation of turbulence, turbulent modeling of compressible flows. Heat transfer for single-phase and for (multi-phase) phase change case.

Text Books:

i) Tannehill, J.E., Anderson, D.A., and Pletcher, R.H., Computational Fluid Mechanics and Heat Transfer, 2nd ed., Taylor & Francis, 1997.
ii) Muralidhar, K and T. Sundararaja, Computational Fluid flow and Heat Transfer, SecondEdition, Narosa publishing house.

Reference Books:

i) Patankar, S.V., Numerical Heat Transfer & Fluid Flow, Hemisphere, 1980.
ii) Versteeg, H.K. and Malalasekera, W., An Introduction to Computational Fluid Dynamics – The finite volume method, Longman Scientific & Technical, 1995.

Course Outcomes:

After going through careful explanations of concepts, numerous practical examples and figures, a student will be able to

CO-No.	Course Outcome	Module Covered
1	Conceptual understanding of underpinning various mathematical models, consistency, stability and fundamentals of fluid flow modelling.	1,2
2	Express numerical modeling and its role in the field of fluid flow and heat transfer.	2,3
3	In-depth understanding of governing equations of FVM and application to fluid flow and heat transfer problem.	3,4
4	Knowledge of various governing equations of FEM and application to fluid flow and heat transfer problem.	4,5
5	Apply the various discretization methods, solution procedures and turbulence modeling to solve flow and heat transfer problems.	1,2,5

Mapping of Course Outcomes with Program Outcomes:

CO	PO1	PO2	PO3	PO-**4**	PO-**5**	PO-**6**	PSO-**1**	PSO-**2**
CO1	3	3	3	2	3	2	3	2
CO2	3	3	3	2	3	2	3	2
CO3	3	3	3	2	3	2	3	2
CO4	3	3	3	2	3	2	3	2
CO5	3	3	3	2	3	2	3	2

DESIGN OF THERMAL SYSTEMS

Semester:	Credit: 4					
Course Name: Design of Thermal Systems	**L**	**T**	**P**	3	1	0

Course Objectives:

1) This course aims to provide a good platform to thermal science and engineering students to understand, model and design systems involving thermal energy transport.
2) Student will be able to design and conduct experiments, as well as to organize, analyze and interpret data to produce meaningful conclusions and recommendations.

Syllabus Content

Module1:

Introduction to thermal System Design; Review of fluid properties and basic governing equations of fluid Mechanics and heat transfer; Introduction to basic instrumentation in thermal science.

Module2:

Design of Piping Systems; Head losses estimation, Design of Piping System- Series and parallel, Design of piping networks.

Module3:

Review of basics of Prime movers, dimensional analysis, pump characteristics, pump selection, Fan Characteristics, Fan selection.

Module4:

Heat Exchanger Design, Design of double pipe Heat exchanger, Design of Shell- and –tube heat exchanger, Design of cross flow heat exchanger, Heat exchanger design option.

Module5:

Basic optimization and soft computing methods- Hill climbing, Simulated annealing, Ant colony optimization, Swarm optimization, Genetic algorithms, Fuzzy optimization; application of optimization in thermal design.

Module6:

Exercise and Design of basic thermo-Fluid Systems.

Text and References:

i) Stoecker, W., Design of thermal Systems, McGraw-Hill.
ii) Jaluria,Y., Design and Optimization of Thermal system , McGraw-Hill.,1998.
iii) Burmeister, L.C.,Elements of thermal-Fluid System design, Printace Hall,1998

Course Outcomes

At the end of the course, Students will be able to

CO-No.	Course Outcome	Module Covered
1	Student will be able to demonstrate and apply in basic governing equations in design and operation of various thermal systems	**1**
2	Student will be able to design thermal systems or components or process to meet the desired conduit and piping systems within realistic constraints such as economic, environmental, safety, manufacturability and sustainability.	**1,2**
3	Student will be able to design thermal systems or components or process considering the appropriate and desired prime mover and heat exchanger within the realistic constraints.	**1,3,4**
4	Student will be able to optimize the design of a thermal systems considering the appropriate method of optimization technique.	**3,4,5**
5	Student will be able to work individually or as a member with responsibility to formulate, design, develop and test basic thermal systems	**5,6**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	3	3	2	2	2	3
CO-2	2	2	3	2	3	3	3	3
CO-3	2	3	3	3	3	2	3	2
CO-4	2	2	2	2	3	3	3	2
CO-5	3	2	3	2	2	2	2	3

TWO PHASE FLOW AND HEAT TRANSFER

Semester:	Credit: 4					
Course Name: Two Phase Flow and Heat Transfer	**L**	**T**	**P**	3	1	0

Course Objectives:

1) This course aims to provide a good platform to the students to understand the phase change principles, different flow system, model and design systems involving two phase flow and associated heat transfer.
2) Studentwillbeabletodesignandconductexperiments,aswellastoorganize,analyzeandinterpretdatato produce meaningful conclusions and recommendations in connection with two phase flow and heat transfer.

Syllabus Content

Module1:

Introduction to Phase change principles, Introduction to multiphase flow, types and applications, Common terminologies, flow patterns and flow pattern maps.

Module2:

Modelling of two phase flow, Interface dynamics, microscopic view point of interfacial interactions, One dimensional steady homogeneous equilibrium flow, homogeneous friction factor, turbulent flow friction factor.

Module3:

The Separated Flow model for stratified and annular flow, Slip, Lockhart-Martinelli method for pressure drop calculation, pressure drop for flow with boiling, flow with phase change. General theory of drift flux model, gravity flows with no wall shear, correction to simple theory, Application of drift flux model to bubbly and slug flow

Module4:

Boiling & Condensation: Fundamentals of boiling, pool and flow boiling, bubble dynamics, heat transfer models, heat transfer correlations, critical heat flux, flow stability, factors affecting boiling, enhancement techniques, practical applications of boiling heat transfer; **Condensation**: Nusselt theory, boundary layer treatment of laminar film condensation, experimental results for vertical and horizontal tubes, condensation inside a horizontal tube, practical applications of condensation

Module5:

Hydrodynamics of solid-liquid and gas-solid flow, Principles of hydraulic and pneumatic transportation.

Module6:

Measurement techniques for two phase flow and heat transfer. Flow regime identification, pressure drop, void fraction and flow rate measurement. Modeling and Simulation of two-phase flow and heat transfer.

Text and References:

i. Brennen, C.E."Fundamentals of Multiphase Flow", Cambridge University Press, NewYork, 2005.
ii. Weber, M. E., Clift, R., Grace, J. R. "Bubbles, Drops, and Particles", Dover Books, NewYork, NY. 2013.
iii. V P Carey, "Liquid-Vapor Phase-Change Phenomena", Hemisphere Pub. Corp. 1992.
iv. L S Tong and Y S Tong," Boiling Heat Transfer and Two Phase Flow",2ndedn.Tailor& Francis,1997
v. Graham B Wallis, "One dimensional two phase flow", McGraw Hill, 1969.
vi. R T Knapp, J W Daily, F G Hammit, "Cavitation", McGraw Hill, 1970.
vii. P de Gennes, F Brochard-Wyart , "Capillarity and wetting phenomena", Springer, 2004.

Course Outcomes

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

CO-No.	Course Outcome	Module Covered
1	Student will be able to demonstrate and apply the basic principle of phase change in the practical two phase flow system	**1,2,3**
2	Student will be able to investigate and design of different flow system along with pressure drop calculation associated with higher dimensional aspects and complexity	**2,3**
3	Studentwillbeabletodesignthermalsystemsorcomponentsorprocessc onsideringtheappropriateapproximationand boundary conditions related with boiling and condensation	**4,5**
4	Studentwillbeabletoanalyze,approximateandapplytheconceptofsolid-liquid and gas-solid flow and their pneumatic transportation	**5**
5	Student will be able to identify and characterize different types of two phase flow regime	**2,5,6**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	3	3	3	2	2	3	2
CO-2	2	2	3	2	3	3	3	2
CO-3	3	3	2	3	2	3	2	3
CO-4	3	2	3	2	2	3	3	3
CO-5	3	3	3	3	2	2	2	3

DESIGN OF COMBUSTION ENGINE

Semester: 1st	Credit: 4					
Course Name: Design of Combustion Engine	**L**	**T**	**P**	3	1	0

Course Objectives:

1) To design the different types of engine components
2) To develop and analyze the various fuel supply systems in CI and SI engines.
3) To relate and compare the combustion and ignition system designs in CI and SI engines
4) To design of Engine cooling systems.

Syllabus Content

Module 1:
Automotive Transmission, Newton Seed.

Module 2:
Analysis of Engine Cycle: analysis of fuel-air & actual cycle.

Module 3:
Power plant for automotive vehicles – details of engine contraction, Reciprocation & Rotary combustion engine, Stratified charged engine, starling engines.

Module 4:
Engine components: Materials, construction & design aspects of engine components, piston assembly, connecting rod, cylinder head, cylinder block, fly wheel, valve-ports, valve, valve actuating mechanism, cams, cam shaft drives, vibration dampers.

Module 5:
Fuel supply in C.I Engine: Carburetion & Mixture requirements, transfer pump, carburetors type, constructional & design aspects, Mixture distribution & inlet manifold, multipoint fuel injection system.

Module 6:
Fuel supply in S.I Engine: Injection system components, jerk & distributor pumps, max &min speed governors, Mech & pneumatic governors, injector & spray characteristics.

Module 7:
Combustion Chamber: Ignition & combustion in SI engine, Flame trouble, Review of detonation & diesel knock fuel, effects of various factors, combustion chamber for SI engine, combustion in CI engine, ignition delay & diesel knock, Excess air supply & air motion, combustion & performance aspect in combustion chamber.

Module 8:
Scavenging & super charging: Scavenging process & efficiencies in 2-stroke engines, super charging power required & effects on engine performance, different types of turbo-charges.

Module 9:
Cooling System: necessity, air cooling system, water cooling system, construction of Radiator, water pump thermostat & cooling fan, antifrize solutions, engine release & cooling system design.

Module 10:
Engine Friction & Lubrication: Friction estimates & lubrication requirements.

Module 11:
Development of I.C Engine: Lean combustion engine, Adiabatic, Duel-fuel, crinkle engines, starling engines & 3-Piston engines**.**

Text Books:

i) Ganesan, V., ―Internal Combustion Engines", 2nd ed., Tata McGraw-Hill, 2003.
ii) Sharma, Mathur,. ―Internal Combustion Engines‖, Dhanpat Rai & Sons.
iii) Crouse, Anglin., ―Automotive Mechanics‖ Tata McGraw-Hill
iv) Kirpal Singh, Automotive Engineering, Vol. I & II, Standards Publishers, New Delhi, 2002..

Reference Books:

i) Heywood J. Internal combustion engine Fundamentals. McGraw-Hill; 1988
ii) Richard Stone. Introduction to Internal Combustion Engines, THE MACMIILLAN PRESS .
iii) The industrial Combustion Engine in Theory & Practice, Vol. I – Charles Faille Taylor.
iv) Internal Combustion Engines – L.C.Lichty.

Course Outcomes

CO-No.	**Course Outcome**	**Module Covered**
1	Design and assemble the various engine components.	**1-4**
2	Synthesize the fuel supply and metering systems in SI and CI engine	**5,6**
3	Modify the combustion systems of SI and CI engines	**7,8**
4	Formulates and reorganize the cooling, lubrication and advanced systems	**9-11**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	1	2	3	3	2	2	3
CO-2	3	2	3	2	2	1	2	2
CO-3	3	1	3	1	2	2	2	1
CO-4	3	2	3	2	1	2	2	3

FINITE ELEMENT METHOD

Semester:	Credit: 4					
Course Name: Finite Element Method	**L**	**T**	**P**	3	1	0

Course Objectives:

1) Enable the student to analyze the engineering problems in the design process of solids and their structure.
2) Make the students to apply the knowledge of mathematics, science and engineering to do the analysis of simple and complex elastic structures using the finite element analysis
3) Derive the finite element equations for different mechanical elements.
4) Learn and apply finite element solutions to structural, thermal, dynamic problem to develop the knowledge and skills needed to effectively evaluate finite element analysis.

Syllabus Content

Module1:

Introduction to FEM, basic concepts, historical back ground, applications of FEM, general description, comparison of FEM with other methods, variational approach, Glerkin's Methods. Co-ordinates, basic element shapes, interpolation function, Virtual energy principle, Rayleigh – Ritz method, properties of stiffness matrix, treatment of boundary conditions, solution of system of equations, shape functions and characteristics, Basic equations of elasticity, strain-displacement relations, Merits and demerits of Fem over FDM and FVM.

Module2:

1-D Structural Problems: Axial bar element – stiffness matrix, load vector, temperature effects, Quadratic shape functions and problems.Analysis of Trusses: Plane Trusses and Space Truss elements and problems, Hermite shape functions – stiffness matrix – Load vector – Problems.

Module3:

Problems: CST, LST, force terms, Stiffness matrix and load vectors, boundary conditions, Isoparametric elements – quadrilateral element, shape functions – Numerical Integration. Finite element modeling of Axi-symmetric solids subjected to Axi-symmetric loading with triangular elements. 3-D Problems: Tetrahedran element – Jacobian matrix – Stiffness matrix.

Module 4:

Steady state heat transfer: One dimensional heat conduction, Boundary condition, One dimensional element, Functional approach for heat conduction, Galarkins approach for heat conduction, One dimensional heat transfer in thin Fins, Two dimensional steady state heat conduction.

Module 5:

Scalar Field Problems: 1-D Heat conduction-Slabs – fins – 2-D heat conduction problems – Introduction to Torsional problems. Dynamic considerations, Dynamic equations – consistent mass matrix – Eigen Values, Eigen vector, natural frequencies – mode shapes – modal analysis.

Text Books:

i) Finite Element Methods: Basic Concepts and applications, Alavala, PHI.
ii) Introduction to Finite Elements in Engineering, Chandrupatla, Ashok and Belegundu, Prentice – Hall

Reference Books:

i) Concepts and Application of Finite Elements Analysis, Cook, Malkus and Plesha, Wiley.
ii) Bathe K.J., "Finite Element Procedures in Engineering Analysis", Prentice Hall of India
iii) O.C.Zienkiewicz, R.L.Taylor & J.Z.Zhu, "The Finite Element Method its Basis and Fundamentals", Butterworth-Heinemann,Elsevier
iv) Finite Element Method, J N Reddy, McGraw Hill International Edition.

Course Outcomes:

At the end of the course, Students will be able to

CO-No.	Course Outcome	Module Covered
1	Apply and understand the basic concepts of Finite element analysis procedure.	1, 2, 3 & 4
2	Analyze and build FEA model for complex engineering problems.	5
3	Knowledge of mathematics and engineering in solving the problems related to structural and heat transfer	4 & 5
4	Develop element characteristic equation and generation of global equation	1, 2, 3 & 4
5	Identify the application and characteristics of FEA elements such as bars, beams, plane and isoparametric elements	1, to 5

CO-PO Mapping: (Rate: scale of1to3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	3	3	3	3	3	2	3
CO-2	3	2	3	2	1	2	3	3
CO-3	3	3	2	1	1	1	2	2
CO-4	3	2	3	2	2	1	2	2
CO-5	3	3	3	1	1	1	2	2

FEM MODELING AND ANALYSIS LABORATORY

Semester:	Credit: 2					
Course Name: FEM Modeling and Analysis Lab	**L**	**T**	**P**	0	0	3

Course Objectives:

1) To acquire basic understanding of Modeling and Analysis software
2) To understand the different kinds of analysis and apply the basic principles to find out the stress and other related parameters of bars, beams loaded with loading conditions.
3) To lean to apply the basic principles to carry out dynamic analysis to know the natural frequency of different kind of beams.
4) To impart the fundamental knowledge on using various analytical tools like ANSYS, FLUENT, etc., for Engineering Simulation.
5) To impart knowledge on how these tools are used in Industries by solving some real time problems using these tools.

List of Experiment

Exp1: Study of a FEA package and modeling and stress analysis of:

a) Bars of constant cross section area, tapered cross section area and stepped bar
b) Trusses – (**Minimum 2 exercises of different types**)
c) Beams – Simply supported, cantilever, beams with point load, UDL, beams with varying load etc (**Minimum 6 exercises different nature**)
d) Stress analysis of a rectangular plate with a circular hole

Exp2: Thermal Analysis – 1D & 2D problem with conduction and convection boundary conditions (Minimum 4 exercises of different types)

Exp 3: Dynamic Analysis to find

a) Fixed – fixed beam for natural frequency determination
b) Bar subjected to forcing function
c) Fixed – fixed beam subjected to forcing function

Exp 4: (**only for demo and oral exam**)

1) Demonstrate the use of graphics standards to import the model from modeler to solver

2) Demonstrate one example of contact analysis to learn the procedure to carry out contact analysis.

3) Demonstrate at least two different type of example to model and analyze bars or plates made from composite material

Course Outcomes:

At the end of the course, Students will be able to

CO-No.	Course Outcome	Experiment Covered
1	Use the modern tools to formulate the problem, and able to create geometry, descritize, apply boundary condition to solve problems of bars, truss, beams, plate to find stress with different loading conditions.	1 to 4
2	Demonstrate the deflection of beams subjected to point, uniformly distributed and varying loads further to use the available results to draw shear force and bending moment diagrams.	1
3	Analyze the given problem by applying basic principle to solve and demonstrate 1D and 2D heat transfer with conduction and convection boundary conditions.	2
4	Able to appreciate the utility of the tools like Solid works, ANSYS or FLUENT in solving real time problems and day to day problems	1 to 4
5	Use of these tools for any engineering and real time applications.	4

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	3	3	3	3	3	2	3
CO-2	3	2	3	1	1	1	3	3
CO-3	3	2	2	1	1	1	3	3
CO-4	3	2	3	1	1	1	2	2
CO-5	3	2	3	1	1	1	3	3

COMPUTATIONAL FLUID DYNAMICS

Semester: 2nd						Credit: **4**
Subject Name: Computational Fluid Dynamics	L	T	P	**3**	**1**	**0**

Course Objectives:

1) Place CFD in the context of a useful design tool for industry and a vital research tool for thermos-fluid research across many disciplines;
2) Familiarize students with the basic steps and terminology associated with CFD. This includes developing students' understanding of the conservation laws applied to fluid motion and heat transfer and basic computational methods including explicit, implicit methods, discretization schemes and stability analysis;
3) Develop practical expertise of solving CFD problems with a commercial CFD code
4) Develop an awareness of the power and limitations of CFD.

Syllabus Contents

Module 1: Basic Thoughts

Philosophy of Computational Fluid Dynamics, the impact of Computational Fluid Dynamics – some other examples- Automobile and Engineering applications, Industrial Manufacturing applications, Civil Engineering applications, Environmental Engineering applications. The governing equations of fluid dynamics: their derivation, a discussion of their physical meaning and presentation of forms particularly suitable to CFD: Introduction, finite control volume, infinitesimal fluid element, the substantial derivative, divergence of velocity-its physical meaning, physical boundary condition, Comments on the conservation form, shock fitting & shock capturing. Comparison of FDM, FVM and FEM technique.

Module 2: Different Equations:

Mathematical Behavior of Partial Differential Equation – The Impact on CFD: Classification of quasi-linear partial differential equation, a general method of determining the classification of partial differential equations: the eigen value method, general behavior of the different classes of partial differential equation: impact on physical & computational fluid dynamics.

Module 3: Basics of the Numerical Discretization

Basic aspect of Discretization methods; finite difference and finite volume formulations, difference equation, explicit and implicit approaches: definition and contrasts, Errors and an analysis of stability.

Module 4: Numerical Solutions

Numerical solution of elliptical equations - Linear system of algebraic equations, Numerical solution of parabolic equations, Numerical solution of hyperbolic equations - Burgers equation.

Module 5: Some Simple CFD Techniques

The lax-Wendroff Technique, MacCormack's Technique, The Relaxation Technique & its use with Low-Speed Inviscid flow, Aspects of Numerical Dissipation and Dispersion; Artificial Viscosity, The Alternating Direction Implicit (ADI)Technique. Incompressible Navier-Stokes equations and algorithms - Basics of grid generation.

Text Books:

i) J.Andeson J.D., Computational Fluid Dynamics – The basics with applications, Mc Graw-Hill, 1995.

ii) Tannehill, J.e., Anderson, D.A., and Pletcher, R.H., Computational Fluid Mechanics and HeatTransfer, 2nd ed., Taylor & Francis, 1997.

ii) Hoffmann, K.A. and Chiang, S.T., Computational Fluid Dynamics for Engineers, Engineering Education Systems, 2000.

Reference Books:

i) Versteeg, H.K. and Malalasekera, W., An Introduction to Computational Fluid Dynamics – The finite volume method, Longman Scientific & Technical, 1995.

ii) Patankar, S.V., Numerical Heat Transfer & Fluid Flow, Hemisphere, 1980.

iii) 3.P.J. Roache, Fundamentals of Computational Fluid Dynamics.

Course Outcomes:

After going through careful explanations of concepts, numerous practical examples and figures, a student will be able to

CO-No.	Course Outcome	Module Covered
CO-1	Comprehensive, theory-based understanding, fundamentals of computational fluid dynamics and its application, Conceptual understanding of mathematical behavior of partial differential equation and its impact on CFD.	1,2
CO-2	In-depth understanding of basic aspect of discretization methods and its applications.	2,3
CO-3	Application of established engineering methods to Numerical solutions.	3.4
CO-4	Understand Some Simple CFD Techniques.	4
CO-5	Understand and apply different algorithms, CFD technique and Basics of various grid generation.	1,4,5

Mapping of Course Outcomes with Program Outcomes:

CO	PO1	PO2	PO3	PO-**4**	PO-**5**	PO-**6**	PSO-**1**	PSO-**2**
CO1	3	3	3	2	3	2	3	2
CO2	3	3	3	2	3	2	3	2
CO3	3	3	3	2	3	2	3	2
CO4	3	3	3	2	3	2	3	2
CO5	3	3	3	2	3	2	3	2
CO6	**3**	**3**	**3**	**2**	**3**	**2**	**3**	**2**

ALTERNATIVE FUELS AND ENERGY SYSTEMS

Semester:	Credit: 4					
Course Name: Alternative Fuels and Energy Systems	**L**	**T**	**P**	3	1	0

Course Objectives:

1) To understand technological, environmental, and social impacts of alternative fuels and its production technologies.
2) To develop and compare the various Alternative fuels from different sources.

Syllabus Content

Module 1:

Introduction: Estimates of petroleum reserve, Need for alternative fuel, Availability and comparative properties of alternate fuels, use of alcohols, LPG, Hydrogen, CNG and LNG, Vegetable oils and Biogas in automotive engines, Relative merits and demerits of various alternative fuels, Potential of Electronic vehicle, Solar car.

Module 2:

Alcohols: Manufacture of alcohols, Properties as engine fuels alcohols and gasoline blends, Performance in S.I engines: Methanol and gasoline blends, effects of compression ratio, alcohols in stratified charge engines, combustion characteristics in engines, reformed alcohols, Use in C.I Engines – Ignition accelerators, alcohols diesel emulsions, duel fuel systems, spark assisted diesel engines, surface ignition engines.

Module 3:

Natural Gas, LPG, Hydrogen: Availability of CNG, properties, Modification required to use in Engines, Performance and emission characteristics of CNG, Using LPG in SI and CI Engines, Performance and emission data for LPG, Hydrogen – production method, Storage and handling, Performance, Safety aspects.

Module 4:

Vegetable Oils and Biogas: Various vegetable oils for engines, Esterification performance in engines, Using biogas in engines, performance and emission characteristics, shale oil, coal liquid and Tars and fuel – Performance and Emission characteristics.

Module 5:

Electric Vehicle: Layout of an electric vehicle, Advantages and limitation specifications, System components, Electric control system, High energy and power density batteries, Hybrid vehicles.

Module 6:

Sterling Engine and its Systems: Constructional and Operational aspects.

Text Books:

- i) Ganesan, V., —Internal Combustion Engines", 2nd ed., Tata McGraw-Hill, 2003.
- ii) Sharma, Mathur,. —Internal Combustion Engines‖, Dhanpat Rai & Sons.
- iii) Michael F. Hordeski -Alternative Fuels: The Future of Hydrogen
- iv) M.K. Gajendra Babu, K.A. Subramanian--Alternative Transportation Fuels Utilisation in Combustion Engines

Reference Books:

- i) Heywood J. Internal combustion engine Fundamentals. McGraw-Hill; 1988
- ii) Richard Stone. Introduction to Internal Combustion Engines, THE MACMIILLAN PRESS .
- iii) Arthur H. Lefebvre, Dilip R. Ballal---Gas Turbine Combustion: Alternative Fuels and Emissions, Third Edition
- iv) Handbook of Alternative Fuel Technologies Edited By Sunggyu Lee, James G. Speight, Sudarshan K. Loyalka

Course Outcomes

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

CO-No.	Course Outcome	Module Covered
1	To investigates and compare different sources of alternative fuels.	**1-4**
2	To develop and study the production technologies and use of alcohols, biofuel, biogas, LPG and hydrogen in CI and SI engines	**1-4**
3	To compare the performance, combustion and emission characteristics of different alternative fuels.	**1-4**
4	To study and investigates different aspects of electric vehicle and sterling engine.	**5,6**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	2	2	3	2	3	2
CO-2	3	3	2	1	2	2	2	2
CO-3	3	1	3	2	2	1	2	3
CO-4	3	2	3	2	1	2	3	2

COMPRESSIBLE FLOW

Semester:	Credit: 4					
Course Name: Compressible Flow	**L**	**T**	**P**	3	1	0

Course Objectives:

1) This course provides the basic and applied understanding of Thermodynamics and Fluid mechanics to mechanical engineering students and transforms the knowledge to industry.
2) The treatment of compressible flow becomes the backbone of aerodynamic engineers towards research in the design of high-speed vehicles- NOT Cleat
3) The contents of the course start with compressible fluid flow followed by governing equations. Many aerodynamic high-speed facilities and their measurement diagnostics governed by these theories are also covered in this course.- NOT Clear

Syllabus Content

Module1:

Basic concepts of Fluid Mechanics, concepts of continuum, forces acting on moving fluid, kinematic properties of fluid, dynamics of fluid motion and fundamental review of Thermodynamics.

Module2:

Introduction to compressible flow, density change, differences between compressible and incompressible flow, governing equations for one dimensional compressible flow, Governing equations for inviscid-compressible flows-static and stagnation properties, Equations/conditions and methods for subsonic and supersonic flows, flow regimes, Mach waves, acoustic speed, pressure wave disturbances in compressible medium, development of compression and expansion waves.

Module 3:

Governing equations of quasi-one dimensional isentropic flow, area-velocity relation and isentropic flow through variable area passage ducts, adiabatic flow,chocking of flow, isentropic flow in a stream tube, concepts of nozzle, convergent-divergent nozzle and diffuser for compressible flow, flow through convergent-divergent nozzle.

Module 4:

One-dimensional equations for normal shock wave change of entropy across a normal shock, Crocco’s theorem, Rankine Huguenot equation and reflected shock waves. Expansion waves and oblique shocks, Prandtl-Meyer expansion wave, equation of motion for oblique shock wave, basic concepts of attached and detached shock waves, reflection and interaction of shocks and expansion wave.

Module 5:

Compressible flow with friction and heat transfer, flow in a constant area duct with friction, Fanno line and Rayleigh line flow, flow with heating and cooling in a constant area duct.

Module 6:

Experimental facilitates and measurement diagnostics of compressible flow, pressure and temperature measurements, introduction to flow visualization and high speed wind tunnels, shock tunnels and shock tubes.

Text Books:

i) Yahya, S.M., Fundamentals of Compressible Flow with Aircraft and Rocket Propulsion, 3rd ed., New Age International Publishers, 2003.
ii) Oosthuizen, P.H. and Carscallen, W.E., Compressible Fluid Flow, McGraw-Hill, 1997.
iii) Zucker, R.D. and Biblarz, Fundamentals of Gas Dynamics, 2nd ed., John Wiley.
iv) Fundamentals of Compressible Fluid Dynamics- P. Balachandran-PHI.

Reference Books:

i) John D. Anderson Jr (1990), Modern Compressible Flow with Historical Perspective, McGraw-Hill, Singapore.
ii) J. John and T. Keith (2010), Gas Dynamics. 3rd Edition, Pearson, New Delhi
iii) Robert D. Zucker and Oscar Biblarz (2002) Fundamentals of Gas Dynamics, Hohn Wiley and Sons Inc, New Jersy, USA
iv) E. Rathakrishnan (2012), Gas Dynamics, 4th Edition, PHI Learning Private Limited, New Delhi
v) Bertin J J and Cummings R M, Aerodynamics for Engineers, 6th Edition, Pearson (2013).

Course Outcomes:

At the end of the course, Students will be able to

CO-No.	Course Outcome	Module Covered
1	Explain the basic concepts of gas dynamics.	2
2	Describe the basic fundamental equations of one dimensional flow of compressible fluid and isentropic flow of an ideal gas.	1, 3
3	Analyze the steady one dimensional isentropic flow, frictional flow, isothermal flow and shock waves.	2, 4
4	Express the concepts of steady one dimensional flow with heat transfer.	5
5	Discuss the effect of heat transfer on flow parameters.	5, 6

CO-PO Mapping: (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	1	--	1	1	-	1	1	--
CO-2	--	--	2	2	1	2	1	2
CO-3	3	2	2	3	1	3	1	3
CO-4	1	2	--	3	1	1	1	-
CO-5	2	1	1	3	--	2	1	1

TWO PHASE FLOW AND HEAT TRANSFER LABORATORY

<table>
<tr><td>Semester: 1st</td><td colspan="6">Credit: 2</td></tr>
<tr><td>Course Name: Two Phase Flow and Heat Transfer Laboratory</td><td>L</td><td>T</td><td>P</td><td>0</td><td>0</td><td>3</td></tr>
</table>

Course Objectives:

1) To demonstrate and apply theory and experimentation in Two Phase Flow Heat Transfer
2) To inculcate and train about error and accuracy in measuring system, types of inputs, analog and digital signals, standards, calibration and uncertainty in measurement system.
3) To orient students for analysis of experimental data, error analysis, uncertainty analysis, data reduction techniques, statistical analysis of data, probability distributions and curve fitting.
4) To give practical exposure to students related to thermometry-heat flux measurement– thermos- physical properties. able to understand physical phenomena, basic concepts and principles of boiling heat transfer, able to identify the techniques to enhance the heat transfer in particular boiling applications and be able to understood different surface modified coating techniques
5) To give exposure related to safety and standards in a workplace.

List of Experiments

Exp 1: Introduction of different instruments and equipments used in two phase flow heat transfer system and engineering applications.

Exp 2: Introduction in measurement of Error estimation and statistical applications in two phase flow measurements.

Exp 3: Introduction for understanding of morphology of enhanced boiling surfaces using different methodologies

Exp4: Study of pool boiling heat transfer of saturated liquids at atmospheric pressure

Exp5: Study of pool boiling heat transfer of saturated liquids at sub-atmospheric pressure

Exp6: Study of pool boiling heat transfer of refrigerants at different pressures

Exp7: Study of pool boiling heat transfer of nano-liquids

Exp8: Study of preparation of different enhance surfaces using a) different Coating Techniques b) Chemical etching process c) nanofluid boiling nanoparticles deposition method and uses of surfaces in experiments

Exp 9: Study of surface wettability of different enhanced surfaces using contact angle meter.

Course Outcomes:

At the end of Course, students will be able to

CO-No.	Course Outcome	Experiment Covered
1	Gain confidence in executing experimental investigations & data Analysis	1 to 9

2	Understand and apply knowledge on modern engineering experimentation, including experiment design, calibration, data acquisition, analysis, and interpretation	4,5,6,9
3	Conduct experiments using real-world methodology/data acquisition system with specifications on resolution and accuracy.	4,5,6,9
4	Analyze the data using output variables and uncertainty Analysis for scientific and meaningful representation.	4,5,6,9
5	Design and develop experimental setup for post graduate thesis work.	4,5,6,9
6	Apply practical knowledge for carrying out future thermal Engineering and heat transfer experimental and computational research	1 to 9

CO-PO Mapping (Rate: scale of 1to3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	3	3	2	3	3	1	2
CO-2	3	2	3	2	2	3	2	3
CO-3	2	2	3	1	2	2	3	2
CO-4	3	2	2	2	2	2	2	2
CO-5	3	3	2	3	3	2	2	3
CO-6	3	2	3	2	2	3	2	3

COMPUTATION METHODS IN FLUID FLOW AND HEAT TRANSFER LAB

<table>
<tr><td>Semester: 2nd</td><td colspan="6">Credit: 2</td></tr>
<tr><td>Course Name: Computation Methods in Fluid Flow and heat Transfer Lab</td><td>L</td><td>T</td><td>P</td><td>0</td><td>0</td><td>3</td></tr>
</table>

Course Objectives:

1) To understand and gain knowledge the fundamentals concepts (learned from fluid courses) for the numerical simulation of real life problems
2) To apply the CFD theory to numerically solve the real life fluid flow problem
3) To know the basic approaches for numerical modeling
4) to get a basic understanding about the boundary conditions used in flow problem and mathematical modeling of it.
5) To provide students with the necessary skills to use commercial CFD packages.
6) To carry out research in the area of Computational Fluid Dynamics.

List of Experiments

Exp1: Study of flow in a two dimensional Lid-driven cavity.

Exp2: Study of heat transfer in a two dimensional Lid-driven cavity.

Exp 3: Study of flow characteristic in a pipe bend.

Exp 4: Study of Heat transfer characteristic in a pipe bend.

Exp 5: Study of flow characteristic over an aero-foil

Exp 6: Study of flow and heat transfer characteristic in a heat exchanger.

Exp 7: TERM paper preparation and presentation

Course Outcomes:

CO-No.	Course Outcome	Experiment Covered
1	Able to gain better concept, more clear understanding and firm grasp of the basic principles in CFD with computational fluid flow engineering and sciences	1 to 7
2	Able to get better understanding about the underlying physics behind the phenomena related to fluid flow	1 to 6
3	Developed creative thinking and a deeper understanding and intuitive feel for fluid engineering and sciences	1 to 6
4	Developed necessary skills to bridge the gap between knowledge and the confidence to properly apply knowledge on the broad application area of fluid flow engineering	1 to 6
5	Build up the skills in the actual implementation of CFD methods (e.g. boundary conditions, turbulence modelling etc.) with their own codes	6,7
6	Gain experience in the application of CFD analysis to real engineering designs.	1 to 6

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	3	3	3	3	3	1	2
CO-2	3	2	2	3	2	3	2	2
CO-3	2	3	3	2	2	2	3	2
CO-4	3	3	3	2	2	2	2	2
CO-5	3	3	3	2	3	2	2	3
CO-6	3	3	3	3	2	3	2	3

ENGINE COMBUSTION AND EMISSIONS

Semester: 1st	Credit: 4					
Course Name: Engine Combustion and Emissions	**L**	**T**	**P**	3	1	0

Course Objectives:

1. To introduce the concept of combustion phenomena in IC Engine
2. To develop the knowledge of thermodynamic modelling of combustion
3. To develop knowledge in formation of emission
4. To understand recent trends in emission control devices.

Syllabus Content:

Module 1: Thermodynamics of Combustion

Premixed and diffusion combustion process in IC engines and gas turbines. First and Second Law of Thermodynamics applied to combustion- combustion Stoichiometry- chemical equilibrium, spray formation and droplet combustion. Chemical Kinetics of Combustion: Fundamentals of combustion kinetics, rate of reaction, equation of Arrhenius, activation energy. Chemical thermodynamic model for Normal Combustion. Flames: Laminar premixed – flame speed correlations- quenching, flammability, and ignition, flame stabilization, laminar diffusion flames, turbulent premixed flames-Damkohler number. Burning of Fuels: spray formation & droplet behavior, gas turbine spray combustion, direct injection engine combustion, detonation of liquid – gaseous mixture, combustion of solid fuels, Combustion principles: Combustion – Combustion equations, heat of combustion - Theoretical flame temperature – chemical equilibrium and Dissociation -Theories of Combustion - Flammability Limits - Reaction rates – Laminar and Turbulent Flame Propagation in Engines. Introduction to spray formation and characterization.

Module2: Combustion in S.I engines

Stages of combustion, normal and abnormal combustion, knocking, Variables affecting Knock, Features and design consideration of combustion chambers. Flame structure and speed, Cyclic variations, Lean burn combustion, Stratified charge combustion systems. Heat release correlations.

Module3: Combustion in C.I. Engines

Stages of combustion, vaporization of fuel droplets and spray formation, air motion, swirl measurement, knock and engine variables, Features and design considerations of combustion chambers, delay period correlations, heat release correlations, Influence of the injection system on combustion, Direct and indirect injection systems.

Module 4: Pollutant emissions from IC engines

Introduction to clean air, Pollutants from SI and CI Engines: Carbon monoxide, UBHCs, Oxides of nitrogen (NO-NOX) and Particulate Matter, Mechanism of formation of pollutants, Factors affecting pollutant formation. Measurement of engine emissions-instrumentation, Pollution Control Strategies, Emission norms-EURO and Bharat stage norms. Emission control measures for SI and CI engines. Effect of emissions on environment and human beings.

Module 5: Control techniques for reduction of emission

Design modifications – Optimization of operating factors – Fuel modification – Evaporative emission control - Exhaust gas recirculation – SCR – Fumigation – Secondary Air injection – PCV system – Particulate Trap – CCS – Exhaust treatment in SI engines –Thermal reactors – Catalytic converters – Catalysts – Use of unleaded petrol. Test procedure, instrumentation & emission measurement: Test procedures CVS1, CVS3 – Test cycles – IDC – ECE Test cycle – FTP Test cycle – NDIR analyzer – Flame ionization detectors – Chemiluminescent analyzer – Dilution tunnel – Gas chromatograph – Smoke meters –SHED test.

Text Books:

i) Sara McAllister, Jyh-Yuan, Chen A. and Carlos Fernandez-Pello "Fundamentals of Combustion Processes" Springer, Mechanical Engineering Series, 2011

ii) Stiesch G., "Modelling Engine Spray and Combustion Process" Springer, Heat and Mass Transfer, 2003

iii) Ferguson, C.R. & Kirkpatrick A.T., "Internal Combustion Engines Applied Thermosciences" Wiley, 2015

Reference Books:

i) Ramalingam, K.K., "Internal Combustion Engines", SciTech Publications (India) Pvt. Ltd., 2004.

ii) Ganesan, V, "Internal Combustion Engines", Tata McGraw Hill Book Co., 2003.

iii) John B. Heywood, "Internal Combustion Engine Fundamentals", McGraw Hill Book, 1998.

iv) B.P. Pundir I.C. "Engines Combustion and Emission", Narosa Publishing House, 2010.

v) B.P. Pundir "Engine Combustion and Emission", Narosa Publishing House, 2011.

vi) Mathur, M.L., and Sharma, R.P., "A Course in Internal Combustion Engines", DhanpatRai

vii) Publications Pvt.New Delhi-2, 1993.

viii) Obert, E.F., "Internal Combustion Engine and Air Pollution", International Text Book Publishers, 1983.

ix) Cohen, H, Rogers, G, E.C, and Saravanamuttoo, H.I.H., "Gas Turbine Theory", Longman Group Ltd., 1980.

x) Domkundwar V, "A course in Internal Combustion Engines", DhanpatRai& Co. (P) Ltd, 2002.

xi) Rajput R.K. "Internal Combustion Engines", Laxmi Publications (P) Ltd, 2006.

xii) Willard W. Pulkrabek, "Engineering Fundamentals of the Internal Combustion Engines", Second Edition, Pearson Prentice Hall, 2007.

xiii) Stephen, R. "Turns., Combustion", McGraw Hill, 2005.

xiv) Mishra, D.P., "Introduction to Combustion", Prentice Hall, 2009

xv) Sharma, S. P., "Fuels and Combustion", Tata McGraw Hill, New Delhi, 2001.

xvi) Heywood, "Internal Combustion Engine Fundamentals", McGraw Hill Co. 1988

Course Outcomes:

At the end of course, students will be able to

CO-No.	Course Outcome	Module Covered
1	Understand the concepts of combustion phenomena in energy conversion devices.	1,2,3
2	Apply the knowledge of adiabatic flame temperature in the design of combustion devices.	1,2,3
3	Identify the phenomenon of flame stabilization in laminar and turbulent flames.	1,2,3
4	Apply control techniques for reduction of emission.	4
5	Identify and understand possible harmful emissions and the legislation standards	5

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	2	3	3	2	3	3	2	1
CO-2	2	2	2	2	2	3	2	3
CO-3	2	2	2	2	2	2	3	2
CO-4	2	3	2	3	2	2	2	3
CO-5	2	3	2	2	3	2	2	3