Dr. Babasaheb Ambedkar Technological University

(Established as a University of Technology in the State of Maharashtra)

(under Maharashtra Act No. XXIX of 2014)

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Course Structure and Contents

for

M.Tech. in Thermal Engineering/ Thermal & Fluids Engineering/ Thermal and Heat Power Engineering/ Heat Power Engineering

From 1st Semester- 4th Semester

Vision

The vision of the Department is to achieve excellence in teaching, learning, research and transfer of technology and overall development of students.

Mission

Imparting quality education, looking after holistic development of students and conducting need-based research and extension activities.

Programme Educational Objectives (PEOs)

No.	PEO
PEO1	To train student's withindepth and advanced knowledge to become professional and capable of identifying, analyzing and solving complex problems in the areas of thermal and fluids engineering.
PEO2	To enable post graduates to carry out innovative and independent research work, disseminate the knowledge in Academia/Industry/Research Organizations to develop systems and processes in the related field.
PEO3	To prepare the students to exhibit a high level of professionalism, integrity, effective communication skills and environmental and social responsibility.
PEO4	To provide an academic environment that gives adequate opportunity to the students to cultivate life-long independent learning ability for their successful professional career.

Programme Outcomes (POs)

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

No.	PO
PO1	Acquire, demonstrate and apply advanced knowledge in the area of thermal and fluids engineering.
PO2	Identify problems in the field of thermal and fluids engineering, formulate them and solve by using advanced techniques.
PO3	Conduct independent research and generate new knowledge for the benefit of community, society Industry and country.
PO4	Apply various numerical methods, advanced software and engineering tools to model, analyze and solve thermal engineering problems.
PO5	Work effectively in interdisciplinary teams for solving real life problems in the related field.
PO6	Apply engineering and scientific principles for the effective management of thermal systems.
PO7	Effectively communicate through technical reports, presentations and scientific publications with the engineering community as well as society at large.
PO8	Demonstrate traits of management in handling engineering projects, related finance, and coordinate with workforce towards achieving goals.
PO9	Demonstrate high level of professional and intellectual integrity,ethics of research and scholarly standards.
PO10	Examine critically the outcomes of one's action sand make corrective measures subsequently.
PO11	Demonstrate the ability to work in team in the laboratory in achieving multidisciplinary tasks required for the project.
PO12	Engage in life-long reflective and independent learning with high level of enthusiasm and commitment.

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Abbreviations

PEO:	Program Educational Objectives
PO:	Program Outcomes
CO:	Course Outcomes
L:	No. of Lecture hours (per week)
T:	No. of Tutorial hours (per week)
P:	No. of Practical hours (per week)
C:	Total number of credits
BSH:	Basic Science and Humanity
BSC:	Basic Sciences Course
PCC:	Professional Core Course
OEC:	Open Elective Course
PEC:	Professional Elective Course
BHC:	Basic Humanity Course
ESC:	Engineering Science Course
HSMC:	Humanity Science and Management Course
NCC:	National Cadet Corps
NSS:	National Service Scheme

MASTER OF TECHNOLOGY

(Thermal Engineering/ Thermal & Fluids Engineering/ Thermal and Heat Power Engineering/ Heat Power Engineering)

Syllabus with effect from July 2018

Semester-I

Course Code	Type of Course	Name of the Course	Hours/Week			Credit	Examination Scheme				
							Theory		CA	PR/OR	Total
			L	T	P		TH	Test			
MTE11	PCC	Advanced Thermodynamics	3	1	--	4	60	20	20	--	100
MTE12	PCC	Advanced Heat Transfer	3	1	--	4	60	20	20	--	100
MTE13	PCC	Numerical Methods and Computational Techniques	3	1	--	4	60	20	20	--	100
MTE14A	Elective I	Exergy Analysis of Thermal Systems	3	--	--	3	60	20	20	--	100
MTE14B		Utilization of Solar Energy									
MTE14C		Advanced I.C. Engines									
MTE14D		Design of Air Conditioning Systems									
MTE14E		Nuclear Power Plants									
MTE14F		Convective Heat Transfer									

MTE15A	Elective II	Thermal Energy Storage	3	--	--	3	60	20	20	--	100
MTE15B		Energy Conservation and Management									
ME-XX15C		Hydraulic, Pneumatic and Fluidic Control									
MTE15D		Wind Energy									
MME15E		Finite Element Method									
MTE15F		Steam Engineering									
MTE15G		Pumps, Blowers and Compressors									
BSH16	HSMC	Communication Skills	2	--	--	2	--	--	25	25	50
MTE17	PCC	Thermal Engineering Lab	--	--	3	2	--	--	25	25	50
		Total	**17**	**3**	**3**	**22**	**300**	**100**	**150**	**50**	**600**

Semester-II

Course Code	Type of Course	Name of the Course	Hours/Week			Credit	Examination Scheme				
							Theory		CA	PR/OR	Total
			L	T	P		TH	Test			
MTE21	PCC	Modeling and Analysis in Thermal Engineering	3	1	--	4	60	20	20	--	100
MTE22	PCC	Fluid Dynamics	3	1	--	4	60	20	20	--	100
MTE23A	Elective III	Conservation of Energy in Buildings	3	--	--	3	60	20	20	--	100
MTE23B		Computational Fluid Dynamics									
MTE23C		Advanced Refrigeration									
MTE23D		Design of Heat Exchangers									
MTE23E		Alternative Fuels for I.C. Engines									
MTE23F		Boundary Layer Theory									
MTE23G		Jet and Rocket Propulsion									
MTE24A	Elective IV	Steam and Gas Turbines	3	--	--	3	60	20	20	--	100
ME-XX24A		Mechatronics									
MTE24B		Cryogenic Engineering									

MTE24C		Combustion Engineering									
MMECH24C		Nanotechnology									
MTE24D		Numerical Heat Transfer									
MTE24E		Biomass Energy									
MTE24F		Power Plant Practice and Control									
MTE24G		Micro Fluidics									
MOE25A	Elective V	Research Methodology	3	--	--	3	60	20	20	--	100
MOE25B		Design of Experiments									
MOE25C		Advanced Optimization Techniques									
MOE25D		Environmental Engineering and Pollution Control									
MOE25E		Soft Computing Techniques									
MOE25F		Manufacturing Automation									
MOE25G		Modeling and Simulation									
MTE26	PCC	Seminar	--	--	4	2	--	--	50	50	100
MTE27	PCC	Mini Project	--	--	4	2	--	--	50	50	100
		Total	**15**	**2**	**8**	**21**	**300**	**100**	**200**	**100**	**700**

Semester-III

Course Code	Type of Course	Name of the Course	Hours/Week			Credit	Examination Scheme				
							Theory		CA	PR/OR	Total
			L	T	P		TH	Test			
MMECH31	PCC	Project Management (Self Study Course)	--	--	--	2	--	--	50	50	100
		OR									
MMECH32	PCC	Intellectual Property Rights (Self Study Course)	--	--	--	2	--	--	50	50	100
MTE33	PCC	Project Stage -I	---	--	--	10	--	--	50	50	100
		Total	---	--	--	**12**	--	--	**100**	**100**	**200**

Semester-IV

Course Code	Type of Course	Name of the Course	Hours/Week			Credit	Examination Scheme				
							Theory		CA	PR/OR	Total
			L	T	P		TH	Test			
MTE41	PCC	Project Stage -II	---	--	--	20	--	--	100	100	200
		Total	---	--	--	**20**	--	--	**100**	**100**	**200**

Semester I

Advanced Thermodynamics

MTE11	Advanced Thermodynamics	PCC	3-1-0	4 Credits
Exam Scheme				
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Course Objectives: Objectives of this course are

1. To provide the sufficient knowledge of thermodynamics to apply in real engineering problems
2. To familiarize the students about the thermodynamic relations and process and their use to analysis the given thermal application
3. To understand the gas equations for properties generation

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

CO1	Understand properties of pure substances. Represent various processes with steam on property diagrams, Apply and compare equations of state for real gases
CO2	Derive Maxwell Relations, Clapeyrons Equation etc. and apply these for evaluation of thermodynamic properties.
CO3	Evaluate entropy change for flow and non-flow processes under steady and unsteady conditions.
CO4	Estimate thermodynamic properties of substances in gas or liquid state of ideal and real mixture.
CO5	Predict intermolecular potential and excess property behavior of multi-component systems. Study irreversible processes.

Mapping of course outcomes with program outcomes

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1										
CO2	1		2	1		1						
CO3	2	1		1		1						
CO4	1	1										
CO5	1			1								

Note: 1- Means least contribution, 2- Means medium contribution 3- Maximum contribution

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Course Contents

Unit I

Pure Substance: Introduction, properties and application of thermodynamics to pure substance. Equation of States: Ideal gas equation and its limitations for real gases, other equations of state like Vander walls, Berthelot, Dieterici, Redlich-kwong equations, Bose-Einstein statistic. Fermi-Dirac statistics

Unit II

Thermodynamic Relations Mathematical theorems, Helmoltz and Gibb's function, T-ds equations, Maxwell's relations, energy equations, variation in heat capacities, Clapeyron relation

Unit III

Entropy: The essence of entropy, a law of quantum state, quantum state probability, entropy definition, decrease of exergy principal, exergy analysis of thermal systems (Case study), thermal energy reservoir, mechanical energy reservoir, constituent reservoir.

Unit IV

Composition of gas mixture: mass and molar fraction, P-v-T behavior of gas mixture. Dalton's law of partial pressure, Amagat's law, properties of gas mixture

Unit V

Irreversible thermodynamics: Reversible and irreversible process, the flux postulate, entropy production; heat flux, thermoelectric phenomenon; thermodynamic analysis of the thermocouple, Onseger's reciprocal relation.

Unit VI

Thermodynamic Equilibrium and stability; condition for chemical equilibrium; equilibrium and third law; phase equilibrium; chemical reaction, equation of reaction equilibrium; phase rule; chemical potential of ideal gases and fugacity .

TEXTS/REFERENCES:

1. W.C. Reynolds and H.C. Perkins, *Engineering Thermodynamics*, McGraw-Hill.
2. P.K. Nag, *Engineering Thermodynamics*, Tata McGraw-Hill, 2005 Ed.
3. Michel SAAD*, Engineering Thermodynamics*, McGraw Hill.
4. Jones and Hawkins, *Engineering Thermodynamics*, Prentice Hall India.
5. J.P.Holman, *Engineering Thermodynamics*, McGraw-Hill.
6. Y.A,Cengel and M.A.Boles, *Thermodynamics: an engineering approach*, Tata McGraw-Hill.
7. S.R.Turns, *Thermodynamics Concepts and Applications*
8. P.L.Dhar , Engineering *Thermodynamics, Elsevier Publication*

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Advanced Heat Transfer

MTE12	Advanced Heat Transfer	PCC	3-1-0	4 Credits
Exam Scheme				
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Course Objectives: Objectives of this course are

1. To provide the technical understanding the concepts of heat transfer in the background of real engineering problems
2. To familiarize the students about the importance of heat transfer process apply to industrial applications
3. To understand the heat transfer concepts apply to other domain of thermal engineering in general

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

CO1	Analyze steady state and transient heat conduction problems of real life Thermal systems
CO2	Analyze extended surface heat transfer problems and problems of phase change heat transfer like boiling and condensation
CO3	Apply the basic principles of classical heat transfer in real engineering application
CO4	Analyze the analytical and numerical solutions for heat transfer problem.
CO5	Understand the basic concepts of turbulence and their impact on heat transfer
CO6	Analyze radiation heat transfer problems of various thermal systems

Mapping of COs with POs

POs→ COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2											
CO2	1			1		1						
CO3	1		2									
CO4	1	1		2								
CO5	1											
CO6	1			1								

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Course Contents:

UNIT-I:

Brief introduction to different modes of heat transfer: conduction: general heat conduction equation-initial and boundary conditions.

Finite difference methods for conduction: id & 2d steady state and simple transient heat conduction problems-implicit and explicit methods.

UNIT-II

Transient heat conduction: lumped system analysis, Heisler charts, semi infinite solid, use of shape factors in conduction, 2d transient heat conduction, product solutions.

UNIT-III:

Forced Convection: Equations of fluid flow-concepts of continuity, momentum equations, derivation of energy equation-methods to determine heat transfer coefficient: Analytical methods-dimensional analysis and concept of exact solution. Approximate method, integral analysis.

UNIT-IV:

External flows: Flow over a flat plate: integral method for laminar heat transfer coefficient for different velocity and temperature profiles. Application of empirical relations to variation geometries for laminar and turbulent flows.

Internal flows: Fully developed flow: integral analysis for laminar heat transfer coefficient-types of flow-constant wall temperature and constant heat flux boundary conditions hydrodynamic &thermal entry lengths; use of empirical correlations.

UNIT-VI:

Free convection: Approximate analysis on laminar free convective heat transfer, Boussinesque approximation, different geometries, combined free and forced convection.

Boiling and condensation: Boiling curve, correlations, Nusselts theory of film condensation on a vertical plate, assumptions & correlations of film condensation for different geometries.

UNIT-V:

Radiation heat transfer: Radiation, shape factor, analogy, shields, radiation of gases & vapors.

Text/References:

1. YunusA.Cengal, *Heat and Mass Transfer* – A practical Approach, 3rd edition, Tata McGraw - Hill, 2007.
2. Holman.J.P, *Heat Transfer*, Tata Mc Graw Hill, 2002.
3. S. P.Sukhatme, *A Textbook on Heat Transfer*
4. Ozisik. M.N., *Heat Transfer – A Basic Approach*, McGraw-Hill Co., 1985
5. Incropera F.P. and DeWitt. D.P., *Fundamentals of Heat & Mass Transfer*, John Wiley & Sons, 2002.
6. Ghoshdastidar. P.S.*, Heat Transfer*, Oxford University Press, 2004
7. M.M. Modest, *Radiative Heat Transfer*, Tata-McGraw-Hill

Numerical Methods & Computational Techniques

MTE13	Numerical Methods & Computational Techniques	PCC	3-1-0	4 Credits
Exam Scheme				
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Course Objectives: Objectives of this course are

1. To inculcate subject knowledge of numerical methods applied to thermal engineering applications
2. To learnt the numerical techniques useful to apply in the areas such as CFD etc.
3. To extent the learning of Numerical method applying the computer programming

Course Outcomes: At the end of the course, student should be able to

CO1	Solve a set of algebraic equations representing steady state models formed in engineering problems
CO2	Fit smooth curves for the discrete data connected to each other or to use interpolation methods over these data tables
CO3	Predict the system dynamic behavior through solution of ODEs modeling the system
CO4	Solve PDE models representing spatial and temporal variations in physical systems through numerical methods.
CO5	Demonstrate proficiency of using MATLAB, VB, ANSYS, EES etc.,

Mapping of COs with POs:

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		2	1									
CO2			1									
CO3	1					1						
CO4		1		2				1				
CO5		1		1							1	2

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Course Contents:

Unit I

Introduction to Numerical Analysis: Objectives, Mathematical Modeling, Programming Concepts, MATLAB, FORTAN etc., Computational Accuracy, Precision, Truncation Errors, Taylor Series

Curve fitting and Regression, Interpolation, Fourier Series concepts

Unit II

Roots of equations: Bisection, False position, Fixed Point Iteration, Newton-Raphson, Secant methods, Roots of polynomials

Linear Algebraic Equations, Gauss Elimination

Unit III

Non-linear Systems of Equations, Gauss-Jordan, LU Decomposition and Matrix Inversion, Gauss-Seidel.

Unit IV

Numerical Integration: Trapezoidal and Simpson's Rules, Gaussian Quadrature.

Numerical Differentiation and finite-difference approximations .

Unit V

Ordinary Differential Equations: Euler's and Runge-Kutta Methods, Boundary-Value, Eigen value and Eigen vector Problems .

Unit VI

Partial Differential Equations: Elliptic Equations, Laplace Equation and Boundary Conditions, Control Volume Approach, Parabolic Equations, Explicit and Implicit Methods, Crank-Nicolson, Introduction to Finite Element Methods.

TEXTS / REFERENCES:

1. Steven C. Chapra and Raymond P. Canale, Numerical Method for Engineers, 6th Edition, McGraw-Hill, 2010.
2. S.S. Sastry, Introductory Methods of Numerical Analysis, 5th Edition, PHI Learning, 2012
3. S. P. Venkateshan, Computational Methods in Engineering, 1st Edition, Academic Press, 2013
4. S.K. Gupta, Numerical Methods for Engineers, New Age International, 2009
5. Gilbert Strang, Computational Science and Engineering, Wellesley-Cambridge, 2007
6. K. Atkinson and W. Han, Elementary Numerical Analysis, 3rd Edition, Wiley-India, 2004.
7. J. D. Hoffman and Steven Frankel, Numerical Methods for Engineers and Scientists, 2nd Edition, McGraw-Hill, 2001
8. S. D. Conte and Carl de Boor, Elementary Numerical Analysis - An Algorithmic Approach, 3rd Edition, McGraw-Hill, 1980

Exergy Analysis of Thermal Systems

MTE14A	Exergy Analysis of Refrigeration Systems	PEC	3-0-0	3 Credits
Exam Scheme				
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Course Objectives: Objectives of this course are

1. To provide the concept, applications, importance of exergy
2. To familiarize the students about the exergy and its applications in real life situations
3. To carry out a exoeconomic analysis on the existed thermal system

Course Outcomes:

At the end of the course, student should be able to:

CO1	Identify and apply concepts, theorems of thermodynamics to the different thermal and fluid engineering system
CO2	Analyze performance these systems by conducting experiments by applying heat balance method, Carnot cycle method and entropy generation methods.
CO3	Interpret and estimate exergy losses by , exergy calculations, exergetic efficiency, exergy charts.
CO4	Apply and concepts of exergy analyses in Specific applications to the analysis of power stations, refrigeration installations, Cryogenic systems and small capacity units.

Mapping of COs with POs:

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1			1								
CO2				2								1
CO3	1											1
CO4	1					1						2

Course Contents:

UNIT I

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

UNIT II

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

UNIT III

Exergy Analysis of Power Plant Cycles: Maximum power subject to size constraint with fixed heat input and its application to Brayton cycle Steam turbine power plants: External and internal irreversibility, superheater, reheater, vacuum condenser, regenerative feed water heating ,combined feed water heating and reheating.

UNIT IV

Gas turbine power plant: External and internal irreversibility, regeration, reheater, and intercooler, combined steam and gas turbine power plant.

UNIT V

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

UNIT VI

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

TEXTS / REFERENCES:

1. Advanced Engineering Thermodynamics by Adrian Bejan, John Wiley & Sons, Inc.
2. The Exergy Method of Thermal Plant Analysis by T J Kotas, Krieger Publishing Company
3. Thermal Design and Optimization by Adrian Bejan, George Tsatsaronis, Michael Moran, John Wiley & Sons, Inc.
4. Advance Thermodynamics for Engineers by Winterbore D E, Arnold Publication
5. Advanced Thermodynamics for Engineers by Kenneth Wark, McGraw Hill Publishing Co. Ltd.

6. Fundamentals of Engineering Thermodynamics by Michel J Moran, Howard N Shapiro, Daisie D Boettner, Margaret B Bailey, John Wiley & Sons, Inc

Utilization of Solar Energy

MTE14B	Utilization of Solar Energy	PEC	3-0-0	2 Credits
Exam Scheme				
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Course Objectives: Objectives of this course are

1. To provide the sufficient knowledge of concept, applications, importance of solar energy
2. To familiarize the students about the solar energy and its applications in real life situations
3. To carry out a case study on the existed solar energy system

Course Outcomes:

At the end of the course, student should be able to:

CO1	Describe measurement of direct, diffuse and global solar radiations falling on horizontal and inclined surfaces, Basic earth sun angles, Beam and diffuse radiations, Radiation on titled surfaces.
CO2	Analyze the performance by conducting research on flat plate collector, air heater and concentrating type collector.
CO3	Understand test procedures and apply these while testing different types of collectors.
CO4	Demonstrate and Design various types of thermal energy storage systems.
CO5	Analyze payback period and annual solar savings due to replacement of conventional systems
CO6	Demonstrate the importance of solar energy effectively to increase awareness of it in society.

Mapping of COs with POs:

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1			1								
CO2				1								
CO3				1								1
CO4									1			
CO5						2						
CO6			2		1							1

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Course Contents

Unit-I

Solar Radiation Analysis: Solar constant, Basic earth sun angles, Beam and diffuse radiations, Radiation on titled surfaces (estimation), Measurement of solar radiation (calibration of equipments)

Unit-II

Heat Transfer for Solar Energy Utilization: Basic models of heat transfer, Radiation characteristics of opaque materials and partially transparent media, Heat transfer analysis for flat plate collectors.

Flat Plate Collectors: Physical principles of conversion of solar radiation into heat, Thermal losses and efficiency of FPC, Practical considerations for flat plate collectors, Applications of FPC – Water heating and Drying

Unit-III

Focusing Type Collectors: Orientation and sun tracking systems, Types of concentrating collectors – Cylindrical parabolic collector, Compound parabolic collector, Thermal performance of focusing collectors, Testing of solar collectors.

Unit-IV

Solar cooking, Solar desalination, Solar ponds and Solar space heating Solar Industrial process heating and Solar power generation.

Unit-V

Solar Green Houses, Solar thermo mechanical power, Solar refrigeration & air conditioning and Solar High Temperature Applications

Unit-VI

Energy Storage for Solar Energy Utilization: Importance of storage systems, Different types of thermal storage systems, Alternate storage methods

Texts / Reference Books:

1. John A Duffie& William A Beckman : “Solar Energy Thermal processes” – Wiley Inter science publication
2. H P Garg & J Prakash “Solar Energy – Fundamentals and Applications: - Wiley Inter science
3. G D Rai “Solar Energy Utilization” – Khanna publishers
4. S P Sukhatme “Solar Energy – Principles of thermal Collection & Storage” – Tata McGraw Hill Publishing company ltd., New Delhi

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Advanced I.C. Engine

MTE14C	Advanced I.C. Engines	PEC	3-0-0	3 Credits
Exam Scheme				
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks		Total 100 Marks

Course Objectives: Objectives of this course are

1. To provide the sufficient knowledge of concept, applications, importance of IC engines
2. To familiarize the students about the IC engines systems, processes, alternative fules etc
3. To understand the environment aspects of IC engines

Course Outcomes:

CO1	Illustrate fundamental and actual thermodynamic cycle analysis in IC engines.
CO2	Describe and simulate actual heat exchange and gas flows in combustion chamber.
CO3	Analyze combustion and apply remedial measures to avoid abnormal combustion in IC engine.
CO4	Apply various emission control system and modification to take corrective actions to reduce pollution.
CO5	Acquire and use knowledge of genetic algorithm to optimize real life problems.
CO6	Understand Modern trends coming in IC Engine technology.

Mapping of COs with POs:

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2		2									
CO2	1		1	2								
CO3	1	2	1	1				1				
CO4						1				1		1
CO5		1	2									
CO6	1	2		2						1		2

Course Contents

UNIT I
Spark Ignition Engines

Mixture requirements, Fuel Induction systems, Stages of combustion, Normal and abnormal combustion, factors affecting knock, Combustion chambers, Engine design, Basic concepts of SI engine simulation technique

UNIT II
Compression ignition engines

Stages of combustion in C.I. Engine, Direct and indirect Injection systems, Combustion chambers, Fuel spray behavior, spray structure, spray characteristics, air motion, engine design, Basic concepts of CI engine simulation technique.

UNIT III

Fuels for SI and CI Engine

Qualities of SI & CI engine fuels, rating of SI & CI engine fuels, fuel additives for SI & CI engines, Fuel supply systems for SI and CI engines to use gaseous fuels like hydrogen, CNG, biogas and, other possible fuels.

UNIT IV

Super-charging and Turbo-charging

Purpose of supercharging, effects of supercharging on SI & CI engines performance and its limitations, different types of turbo-charges, methods of turbo charging & its limitations.

UNIT V

Engine Emissions & Control: Air pollution due to IC engines, Emissions-HC, CO, NOx, particulates, GHGs (CO_2, CH_4 and N_2O), emission norms, emission control methods-exhaust gas recirculation, three-way catalytic convertor, particulate trap, modern methods.

UNIT VI

Recent Trends

Homogeneous Charge Compression Ignition Engine, Lean Burn Engine, Stratified Charge Engine, Electronic Engine Management, Common Rail Direct Injection Diesel Engine, Gasoline Direct Injection Engine, Data Acquisition System –pressure pick up, charge amplifier PC for Combustion and Heat release analysis in Engines.

Reference Books:

1. E.F. Obert, Internal Combustion Engines and Air Pollution, Intext Educational Publishers, 1973.
2. John B Heywood, Internal Combustion Engine Fundamentals, McGraw Hill
3. M.L. Mathur and R.P.Sharma, Internal Combustion Engines, DhanapatRai Publications, New Delhi.
4. L.C. Litchy, Combustion Engines Processes, McGraw Hill, 1967.
5. V. Ganesan, Int. Combustion Engines, II Edition, TMH, 2002.
6. V. Ganesan, Computer simulation of spark ignition process: University process, Hyderabad 1993.

Design of Air-Conditioning Systems

MTE14D	Design of Air-Conditioning System	PEC	3-0-0	3 Credits
Exam Scheme				
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Course Objectives: Objectives of this course are

1. To provide the sufficient knowledge of concept, applications, importance of air conditioning
2. To familiarize the students about the air conditioning system design and its applications in real life situations
3. To learn the duct design and load calculation

Course Outcomes:

At the end of the course, student should be able to:

CO1	Demonstrate Air-conditioning processes and psychometric
CO2	Illustrate Ventilation, Necessity, Natural Ventilation, wind effect, Measurement of thermal comfort indices.
CO3	Formulate and solve problems of cooling, heating load calculations.
CO4	Design Air distribution, duct design for suitable problem.
CO5	Analyze Sound propagation, SPL, PWL, Sound Intensity, room acoustics and apply noise control techniques.

Mapping of COs with POs:

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2											
CO2	1											
CO3		2		2								
CO4		1			1	1						
CO5				1								

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Course Contents

Unit I

Psychrometry, Air-conditioning processes, Advanced psychrometry, ERSHF, winter air-conditioning, Preparation of psychrometric charts.

Unit II

Ventilation, Necessity, Natural Ventilation, wind effect, stack effect, flow around building, Thermal Comfort, Thermal human model, Measurement of thermal comfort indices.

Unit III

Solar geometry, Building Heat Transfer, Cooling Load Calculation, CLTD Method Cooling Load and Heat Loss calculations, Concept of energy days, Heating load calculation.

Unit IV

Room Air Diffusion, Filtration, Duct Design for real life applications such as hospitals , hotels, shopping malls etc., Air Distribution Design.

Unit V

Noise control, Sound propagation, SPL, PWL, Sound Intensity, room acoustics, sound control in ducts.

Unit VI

HVAC Equipment, Packaged and Split HVAC Equipment, Heat pump Design and selection, Equipment Selection, Auxiliaries.

TEXTS / REFERENCES:

1. Handbook of Air Conditioning System Design, Carrier Air Conditioning Co., 1965.
2. ASHRAE Handbooks and ISHRAE Handbooks
3. Thermal Environmental Engineering, James L.Threlkeld, Prentice Hall,
4. Air conditioning engineering, W. P. Jones, ELBS
5. Refrigeration and Air-conditioning, Stoecker and Jones, McGraw Hill
6. Edward Pita, Air Conditioning Principles and Systems,Prentice Hall

Nuclear Power Plants

MTE14E	Nuclear Power Plants	PEC	3-0-0	3 Credits
Exam Scheme				
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Course Objectives:

1. To provide the sufficient knowledge of concept, applications, importance of Nuclear Power plant
2. To familiarize the students about the design of Nuclear Power plant
3. To understand the environment impact and policies about the NPP

Course Outcomes:

At the end of the course, student should be able to:

CO1	Identify various energy sources, Indian Power Scenario, Nuclear Power Scenario in the World Nuclear Power Scenario in India, Scope
CO2	Describe Nuclear physics, reactor, classification and types of nuclear reactor, economics of power plant.
CO3	Illustrate effect of nuclear radiation on health, safety and licensing
CO4	Analyze heat transfer from nuclear, heat flux radiation.
CO5	Analyze economics of nuclear power plant, load generation.

Mapping of COs with POs:

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1											
CO2	2						1					
CO3		2					1			1		2
CO4			1	1								
CO5			1									

Course Content

UNIT I

Introduction – World Energy Sources, Indian Power Scenario, Nuclear Power Scenario in the World, Nuclear Power Scenario in India, Scope of the Present Course.

UNIT-II

Nuclear Power Plant: Nuclear physics, Nuclear Reactor, Classification, Types of reactors, Site selection. Method of enriching uranium. Application of nuclear power plant. Nuclear Power

Plant Safety: Bi-Product of nuclear power generation, Economics of nuclear power plant, Nuclear power plant in India, Future of nuclear power.

UNIT III

Basic Concepts in Neutron Reactions, Neutron Moderation and Diffusion, Nuclear Reactor Theory. Nuclear Reactor Dynamics and Control., Nuclear Reactor Thermal-Hydraulics.

UNIT-IV

Power Plant Instrumentations: Classification, Pressure measuring instrument, Temperature measurement and Flow Measurement, Analysis of combustion gases, Pollution types, Methods of control.

UNIT V

Health Physics, Radiation Shielding, Nuclear Reactor Safety and licensing.

UNIT-VI

Economics Of Power Generation: Factors affecting the economics, Loading factors, Utilization factor, Performance and operating characteristics of power plant, Point economic load sharing, Depreciation. Energy rate, Criteria for optimum loading. Specific economic energy problem

REFERENCES:

1. Power Plant Engineering / P.K.Naga / TMH
2. Power Plant Technology / El Wakil, McGraw Hill Publication
3. Power Plant Engineering / P.C.Sharma/ Kotearia Publications.

Convective Heat Transfer

MTE14F	Convective Heat Transfer	PCC	3-0-0	3 Credits
Exam Scheme				
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Course Objective:
Objectives of this course are:
1. To Understand the concept of fluid mechanics in the back ground of Convection heat transfer.
2. To familiarize the students about the convective heat transfer mathematical analysis of various situations.
3. To understand the analysis of convective heat transfer using software

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

CO1	Describe Applications of Convective Heat transfer in various thermal systems.
CO2	Formulate and solve Navier-Stokes equations and energy equations in for various flow patterns and systems.
CO3	Simulate and distinguish convective heat transfer through laminar and turbulent boundary layer by using computer softwares e.g., MATLAB,CFD,EES etc.,
CO4	Analyze natural and combined convection for flows through various channel by using numerical techniques.
CO5	Categorize and illustrate flows through porous media with applying energy equation for fully developed flows.

Mapping of course outcomes with program outcomes

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

CO5												

Course Content:

UNIT I

Introduction to Forced, free & combined convection – convective heat transfer coefficient – Application of dimensional analysis to convection – Physical interpretation of dimensionless numbers.

Equations of Convective Heat Transfer: Continuity, Navier-Strokes equation & energy equation for steady state flows – similarity – Equations for turbulent convective heat transfer – Boundary layer equations for laminar, turbulent flows – Boundary layer integral equations.

UNIT II

EXTERNAL LAMINAR FORCED CONVECTION: Similarity solution for flow over an isothermal plate– integral equation solutions – Numerical solutions – Viscous dissipation effects on flow over a flat plate.

External Turbulent Flows: Analogy solutions for boundary layer flows – Integral equation solutions.

UNIT III

Internal Laminar Flows: Fully developed laminar flow in pipe, plane duct & ducts with other cross-sectional shapes – Pipe flow & plane duct flow with developing temperature field – Pipe flows & plane duct flow with developing velocity & temperature fields.

Internal Turbulent Flows: Analogy solutions for fully developed pipe flow –Thermally developing pipe & plane duct flow.

UNIT IV

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

UNIT V

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

UNIT VI

CONVECTIVE HEAT TRANSFER THROUGH POROUS MEDIA: Area weighted velocity – Darcy flow model – energy equation – boundary layer solutions for 2-D forced convection – Fully developed duct flow – Natural convection in porous media – filled enclosures – stability of horizontal porous layers.

REFERENCES:

1. Introduction to Convective Heat Transfer Analysis/ Patrick H. Oosthuigen & David Naylor /McGraw Hill

2. Convective Heat & Mass Transfer /Kays & Crawford/TMH
3. Bejan, Convective Heat Transfer

Thermal Energy Storage

MTE15A	Thermal Energy Storage	PEC	3-0-0	3 Credits
Exam Scheme				
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Course Objectives:

1. To provide the sufficient knowledge of concept, applications, importance of Thermal energy storage
2. To familiarize the students about the design of thermal energy storage systems
3. To understand the industrial applications of thermal energy storage

Course Outcomes:

At the end of the course, student should be able to:

CO1	Survey litterateur on importance of energy transport and storage of thermal, mechanical, electro chemical energies etc.,
CO2	Interpret and analyze energy storage and conversion performance from one to another.
CO3	Design system for Chemical energy storage (organic fuels) High temperature storage Compressed air energy storage

Mapping of COs with POs:

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2										
CO2		1		1	1							
CO3			1	1		1						

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Course Contents

Importance and modes of energy transport and storage
Thermal energy storage (sensible and latent heat storage)
Mechanical Energy Storage: gravitational energy storage, elastic energy storage

Electromagnetic energy storage: static field, transient electric field, magnetic materials, radiant storage.

Electro-chemical energy conversion and storage: The electrochemical cell, Fuel cells, batteries.
Chemical energy storage (organic fuels)
High temperature storage
Compressed air energy storage

Thermo chemical storage
Emerging technologies and examples of energy storage
Testing of storage systems

Thermal modeling of energy storage systems
Total energy systems

Texts / Reference Books:

1. Johannes Jensen & Bent Sorensen : "Fundamentals of energy storage"
2. Collins : "Batteries Vol. I & II".
3. S.U.Faulk& A.J.S SaIkins : "Silver Zinc - Alkaline storage systems".

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Energy Conservation and Management

MTE15B	Energy Conservation and Management	PEC	3-0-0	3 Credits

Exam Scheme			
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks

Course Objectives: Objectives of this course are

1. To provide the sufficient knowledge of concept, applications, importance of Energy Conservation and management
2. To familiarize the students about the Energy audit and its applications in real life situations
3. To carry out a energy audit on the existed thermal system

Course Outcomes::

At the end of the course, student should be able to:

CO1	Demonstrate energy management principles, identify need, organizing it. carry out energy auditing.
CO2	Conduct economic analysis of any industry or power plant, obtain conclusion and suggest it to industry.
CO3	Interpret financial appraisal methods, and thermodynamic analysis, and estimate financial budget of visited industry.

Mapping of COs with POs:

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2										
CO2			1	1		1		2				
CO3				1	1		1	2				1

Course Contents

Unit-I

Energy scenario and its various forms, General energy problem, Energy use patterns, Energy balance.

Energy Management Principles: Need, Organizing, Initiating and managing an energy management program.

Energy Auditing: Elements and concepts, Types of energy audits, Instruments used in energy auditing.

Unit-II

Economic Analysis: Cash flows, Time value of money, Formulae relating present and future cash flows - single amount, uniform series.

Unit-III

Financial appraisal methods: Payback period, Net present value, Benefit-cost ratio, Internal-rate of return & Life cycle costs/benefits.
Thermodynamics of energy conservation, Energy conservation in Boilers and furnaces, Energy conservation in Steam and condensate system.

Unit-IV
Cogeneration: Concepts, Types of cogeneration systems, Performance evaluation of a cogeneration system.
Waste Heat Recovery: Potential, benefits, waste heat recovery equipments.
Space Heating, Ventilation Air Conditioning (HVAC) and water heating of building, Transfer of heat, Space heating methods, Ventilation and air conditioning, Heat pumps, Insulation, Cooling load, Electric water heating systems, Electric energy conservation methods.

Unit-V
Industrial Insulation: Insulation materials, Insulation selection, Economical thickness of insulation. Industrial Heating: Heating by indirect resistance, direct resistance heating (salt bath furnace), Heat treatment by induction heating in the electric arc furnace industry.

Unit-VI
Energy Conservation in Electric Utility and Industry: Energy costs and two – part tariff, Energy conservation in utility by improving load factor, Load curve analysis, Energy efficient motors, Energy conservation in illumination systems, Importance of Power factor in energy conservation - Power factor improvement methods, Energy conservation in industries

Texts / Reference Books:

1. S.C.Tripathy: "Electric Energy Utilization and Conservation", TMG Delhi, 1991.
2. Wayne C. Turner: "Energy Management Handbook", Wiley Interscience Publication, NY, 1982.
3. D.A.Reay: "Industrial Energy Conservation", Pergamon Press. 1980.
4. T.L Boten: "Thermal Energy Recovery", Wiley, 1980.
5. Industrial Energy Conservation Manuals: MIT Press.
6. W.C.Turner, Energy Conservation Handbook.

Hydraulic, Pneumatic and Fluidic Control

ME-XX15C	Hydraulic, Pneumatic and Fluidic Control	PEC	3-0-0	3 Credits

Exam Scheme			
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks

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

CO1	Understand the type of control system and their utility
CO2	Describe the hydraulic power generation
CO3	Design pneumatic and hydraulic circuits for a given application
CO4	Discuss steady state operating forces, transient forces and valve instability
CO5	Design of pure fluid digital elements, Lumped and distributed parameter fluid systems

Mapping of course outcomes with program outcomes

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2											
CO2	2				1	1						
CO3	2	2		3	3							
CO4	2					2	3			2		1
CO5	2	2		2	3							

Course Contents:

Unit I

Introduction to control system, types of control system and their utility.

Unit II

Hydraulic power generation and transmission, valve control pressure flow relationship and constructions.

Unit III

Steady state operating forces, transient forces and valve instability.

Unit IV

Circuit design, pneumatic valves, hydraulic and pneumatic drives, introduction to fluidic devices and sensors.

Unit V

Lumped and distributed parameter fluid systems, fluid mechanics of jets, wall attachment and vortex devices.

Unit VI

Pure fluidic analog amplifiers, analog signal control techniques, design of pure fluid digital elements.

Texts / References:

1. J.F.Blackburn, G.Rechthof, J.L. Shearer, *Fluid Power Control*, MIT.
2. B.W.Anderson,*The Analysis and Design of Pneumatic Systems*, Wiley.
3. K.Foster, G.Parker, *Fluidic Components and Circuits*, Wiley.
4. A.B.Goodwin, *Fluid Power Systems*, Macmillan.

Wind Energy

MTE15D	Wind Energy	PEC	3-0-0	3 Credits
Exam Scheme				
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Course Objectives: Objectives of this course are

1. To understand history of wind energy and its scope in future.
2. To get practical knowledge about use various wind energy measurement indicators, anemometers
3. To calculate various parameters of wind turbine.

Course Outcomes: At the end of the course, student should be able to

CO1	Identify and describe history of wind energy and its scope in future.
CO2	survey and analyze through a literature review world distribution of wind,Weibull statistic, variation in wind energy etc.,
CO3	Conduct an experiment to use various wind energy measurement indicators, anemometers, and apply it to analyze and check data obtained from surveys.
CO4	Demonstrate and calculate performance parameters wind energy turbine.
CO5	Illustrate various electrical systems used in wind energy power plant.
CO6	Examine and justify economics of wind system.

Mapping of course outcomes with program outcomes

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	2								
CO2	1		2		1	1					1	
CO3	2	1	1									
CO4	1			2	1	1						
CO5	1	1										
CO6	1	1			1			1				

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Course Contents

Unit I

Introduction: Historical uses of wind, History of wind electric generations.

Unit II

Wind Characteristics: Metrology of wind, World distribution of wind, Atmospheric stability, Wind speed variation with height, Wind speed statistics, Weibull statistics, Weibull parameters, Rayleigh and normal distribution.

Wind Measurements: Biological indicators, Rotational anemometers, other anemometers, Wind direction.

Unit III

Wind Turbine Power, Energy and Torque: Power output from an ideal turbine, Aerodynamics, Power output from practical turbines, Transmission and generation efficiency, Energy production and capacity factor, Torque at constant speeds, Drive train oscillations, Turbine shaft power and torque at variable speeds.

Unit IV
Wind Turbine Connected to the Electrical Network: Methods of generating synchronous power, AC circuits, the synchronous generator, per unit calculations, the induction machine, Motor starting, Capacity credit features of electrical network.
Wind turbines with Asynchronous Electric Generators: Asynchronous systems, DC shunt generator with battery load, Per unit calculation, Self excitation of the induction generators, Single phase operation the induction generator, Field modulated generators, Roesel generator.

Unit V
Asynchronous Load: Piston water pumps, Centrifugal pumps, Paddle wheel heaters, Batteries, Hydrogen economy, and Electrolysis cells.

Unit VI
Economics of Wind Systems: Capital costs, Economic concepts, Revenues requirements, Value of wind generated electricity

Text/Reference Books:

1. Garg L Johnson: "Wind Energy Systems" Prentice Hall. Inc, New Jersey – 1985
2. Desire Le Gouriers: "Wind Power Plants: Theory and Design" Pergamon Press – 1982

Finite Element Method

MME15E	Steam Engineering	PEC	3-0-0	3 Credits
Exam Scheme				

Mid Sem Test	Continuous Assessment	End-Sem Exam	Total
20 Marks	20 Marks	60 Marks	100 Marks

Pre-Requisites: None
Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the basics principle of FE method
CO2	Identify mathematical model for solution of common problems
CO3	Solve structural, thermal problem using FE in 1D Case
CO4	Derive element stiffness matrix by different methods
CO5	Understand the formulation for 2D and 3D case
CO6	Recognize need for and engage in lifelong learning

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1										
CO2	3	3	1		1							1
CO3	2	2	1	2	2				2			1
CO4	3								2			
CO5	3	2										
CO6			1									3

Course Contents:

Unit 1
- 1-D Problems: Introduction to structural analysis and FEM, Introduction to approximate solutions and FEM, summary of linear elastic mechanics.

Unit 2
- 1-D Problems: Principles of linear elastic mechanics, principles of virtual displacements and minimum potential energy, Rayleigh Ritz method, exact v/s approximate solution, beam elements.

Unit 3
- 2-D Problems: Plane stress and plane strain conditions, triangular elements, constant strain triangle, linear strain triangle, Boundary conditions, body forces and stress recovery, quadrilateral elements.

Unit 4

- 2-D Problems: Lagrange and Serendipity shape functions, isoparametric formulation, numerical integration, modeling with isoparametric elements, requirements for convergence, patch test, nonconforming elements, reduced integration.

Unit 5

- 3-D Problems: Axisymmetric solids, governing equations, axisymmetric elements and their applications, mixed formulations, bending of flat plates (Kirchhoff Theory), continuity requirements and boundary conditions.

Unit 6

- 3-D Problems: Discrete Kirchhoff's elements, thick plate elements, plate bending applications, shells as assemblage of flat plates, finite element formulation for dynamic problems, mass properties, introduction to elastic stability for frames and plates.

TEXTS / REFERENCES:

1. R. D. Cook, Concepts and Applications of Finite Element Analysis; John Wiley and Sons, second edition, 1981.
2. C.S. Krishnamurti, Finite element method; Tata Mc-Graw Hill Publication.
3. K.J. Bathe, Finite Element Method and Procedures; Prentice hall, 1996.
4. Tirupathi, R., and Chandrupatla, Finite Elements in Engineering; PHI Publication, New Delhi.
5. Bruce Irons and Soharab Ahmed, Techniques of Finite Elements; John Wiley and Sons, New York.
6. K.J. Bathe, Finite Element Method; Prentice Hall, 1987.
7. O.P., Goptha, Finite and Boundary Element Methods in Engineering; Oxford and IBH.

Steam Engineering

MTE15F	Steam Engineering	PEC	3-0-0	3 Credits
Exam Scheme				
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Course Objectives: Objectives of this course are

1.To Understand of the working of different boilers and accessories..
2.To analyze thermal systems for energy conservation and waste heat recovery.
3.To design and develop controls and instrumentation.

Course Outcomes: At the end of the course, student should be able to:

CO1	Explain working of different boilers and significance of mountings and accessories.
CO2	Use techniques, skills, and modern engineering tools necessary for boiler performance assessment
CO3	Understand theoretical and practical background in thermal systems, and will have a good understanding of energy conservation fundamentals. Students will have the ability to analyze thermal systems for energy conservation.
CO4	Design a steam piping system, its components for a process and also design economical and effective insulation.
CO5	Analyze a thermal system for sources of waste heat design a system for waste heat recovery.
CO6	Design and develop controls and instrumentation for effective monitoring of the process.

Mapping of course outcomes with program outcomes

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2				1			1				
CO2	2	1		3				2		1		
CO3	1	2	1			1						1
CO4	2	1				1	2					1
CO5	1	1	1									1
CO6	2							2				

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Course Content

Unit I

Introduction Fundamentals of steam generation, Quality of steam, use of steam table, Mollier Chart Boilers, Types, Mountings and Accessories, Combustion in boilers, Determination of adiabatic flame temperature, quantity of flue gases, Feed Water and its quality, Blow down; IBR, Boiler standards.

Unit II

Piping & Insulation Water Line, Steam line design and insulation; Insulation-types and application, Economic thickness of insulation, Heat savings and application criteria, Refractory types, selection and application of refractory, Heat loss.

Unit III

Steam Systems Assessment of steam distribution losses, Steam leakages, Steam trapping,Condensate and flash steam recovery system, Steam Engineering Practices; Steam Based Equipment's / Systems.

Unit IV

Boiler Performance Assessment Performance Test codes and procedure, Boiler Efficiency, Analysis of losses; performance evaluation of accessories; factors affecting boiler performance.

Unit V

Energy Conservation and Waste Minimization

Energy conservation options in Boiler; waste minimization, methodology;economic viability of waste minimization.

Unit VI

Instrumentation &Control Process instrumentation; control and monitoring. Flow, pressure and temperature measuring and controlling instruments, its selection.

Texts/References:

1. T. D. Estop, A. McConkey, Applied Thermodynamics, Parson Publication
2. Domkundwar; A Course in Power Plant Engineering; Dhanapat Rai and Sons
3. Yunus A. Cengel and Boles, "Engineering Thermodynamics ", Tata McGraw-HillPublishing Co. Ltd.
4. Book II - Energy Efficiency in Thermal Utilities; Bureau of Energy Efficiency.
5. Book IV - Energy Performance Assessment for Equipment & Utility Systems; Bureau of Energy Efficiency.
6. Edited by J. B. Kitto& S C Stultz; Steam: Its Generation and Use; The Babcock and Wilcox Company
7. P. Chatopadhyay; Boiler Operation Engineering: Questions and Answes; Tata McGrawHill Education Pvt Ltd, N Delhi

Pumps, Blowers and Compressors

MTE15G	Pumps, Blowers and Compressors	PEC	3-0-0	3 Credits
Exam Scheme				
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Course Objectives:

1. To provide the sufficient knowledge of concept, applications, importance of pumps blower and compressors
2. To familiarize the students about the Pumps blowers and compressors and their applications in real life situations
3. To understand the industrial applications of Pumps blowers and compressors

Course Outcomes:

At the end of the course, student should be able to:

CO1	Demonstrate Law of momentum, Vortex theory of Euler's head. Hydraulic performance of pumps, Cavitation,
CO2	Design of centrifugal pumps, axial flow pump and analyze their performance using engineering software's etc.,
CO3	Study types of fans and blowers, calculate their efficiency, stresses, and characteristics, draw performance characteristics.
CO4	Modeling of cooling tower fans Surging Design of blowers and fans.
CO5	Demonstrate and interpret performance analysis of Axial flow and centrifugal flow compressors.

Mapping of COs with POs:

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2											
CO2	1	2										
CO3	1	1										1
CO4		1										1
CO5	1								1			

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Course Contents

Unit I

Centrifugal and Axial Flow Pumps

Law of momentum, Vortex theory of Euler's head.Hydraulic performance of pumps; Cavitation, Losses in Pumps, Priming, Jet pumps. The centrifugal pump, definitions, pump output and efficiency, multistage centrifugal pumps, axial flow pump, Design of pumps, Pumps in series and parallel.

Unit II
Power Transmitting Turbo-machines, Introduction, theory, fluid of hydraulic coupling, torque converter.

Unit III
Rotary fans and blowers Introduction, Centrifugal blower, types of Vane shapes, Size and speed of Machine, Vane shape: efficiency, stresses, and characteristics. Actual performance characteristics, the slip co-efficient, Drum and partial flow fans, Fan laws and characteristics, Losses in fans and blowers.

Unit IV
Turbo blowers and their characteristics. Cooling tower fan, Surging Design of blowers and fans.

Unit V
Axial Compressors: Stage velocity triangles, enthalpy – entropy diagrams, flow through blade rows, stage losses and efficiency, work done factor, low hub-tip ratio stages, super sonic and trans sonic stages, performance characteristics and design.

Unit VI
Centrifugal Compressors: Elements of centrifugal compressor stage, stage velocity diagrams, enthalpy-entropy diagram, nature of impeller flow, slip factor, diffuser, volute casing, stage losses, performance characteristics and design.

TEXT / REFERENCES:

1. A.J.Stepanoff, *Centrifugal and Axial /flow Pumps*, Wiley, 1962.
2. A.Kovats, *Design and Performance of Centrifugal and Axial Flow Pumps and Compressors*, Oxford, Pergamon, 1958.
3. V. Kadambi and Manohar Prasad: "*An Introduction to energy conversion* VolumeIII,2002
4. S M Yahya: "*Turbines, Compressors and Fans*", Second Edition.
5. V Ganesan: "*Gas Turbines*", 2002.
6. R.Yadav, *Steam and Gas Turbine*, Central Publishing Home, Allahabad.

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Communication Skills

BSH16	Communication Skills	HSSC	2-0-0	2 Credits

Pre-Requisites: None
Course Outcomes: At the end of the course, the student will be able to:

CO1	
CO2	
CO3	
CO4	
CO5	
CO6	

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

Course Contents:

UNIT1
Introduction to communication, Necessityofcommunication skills, Features ofgood communication, Speakingskills, Feedback&questioningtechnique, Objectivityin argument

UNIT 2
Verbaland Non-verbalCommunication, Useand importanceof non-verbalcommunication while usinga language, Studyofdifferentpictorialexpressionsofnon-verbalcommunicationand theiranalysis

UNIT 3
Academic writing, Different typesofacademic writing, WritingAssignments and Research Papers, Writingdissertations andprojectreports

UNIT 4
Presentation Skills:Designingan effective Presentation, Contents,appearance,themes in a presentation, Tone and Language in a presentation, Roleand Importance ofdifferenttoolsfor effective presentation

UNIT 5
Motivation/Inspiration:Abilitytoshape anddirectworking methods accordingto self-definedcriteria

Abilitytothinkforoneself,Applyoneselfto ataskindependentlywith self-motivation,Motivation techniques:Motivationtechniques based on needs andfield situations

UNIT 6

SelfManagement,SelfEvaluation,Selfdiscipline, Selfcriticism, Recognitionofone'sown limits and deficiencies,dependency, etc.
SelfAwareness, Identifyingone's strengths andweaknesses, Planningand Goalsetting, Managingself- emotions, ego, pride, Leadership andTeamDynamics

ReferenceBooks:

1. Mitra, Barun, *PersonalityDevelopment and SoftSkills*, Oxford UniversityPress, 2016
2. Ramesh, Gopalswamy, *TheAceof Soft Skills: Attitude, Communication and Etiquette forSuccess*, Pearson Education, 2013
3. Covey, Stephen R.,*Seven Habits of HighlyEffectivePeople: Powerful Lessons in Personal Change*
4. RosenbergMarshallB.,*Nonviolent Communication: A Language of Life*

Thermal Engineering Lab

MTE17	Thermal Engineering Lab	PCC	0-3-0	2 Credits
Exam Scheme				
Continuous Assessment 25 Marks		PR/OR 25 Marks		Total 50 Marks

Course Objectives: Objectives of this course are

1. To apply the theoretical concepts and enhance understanding of the engineering concepts
2. To familiarize the students about the measurements and error calculations during experiments
3. To understand the design of experiments and report writing

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

CO1	Conduct test on heat transfer enhancement set-up, single-cylinder diesel engine, air conditioning set-up, centrifugal pump etc. to study their performance and analyze the results.
CO2	Draw and analyze performance curves of these machines/systems.
CO3	Compare the results obtained with expected theoretical results.

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1		1			2					2	
CO2	1			1								
CO3	2					1						

Contents

Experiments on the following set-ups(Any Four):

1. Heat Transfer Enhancement Set-up
2. Computerised Single-Cylinder Diesel Engine Set-up with Alternative Fuel
3. Set-up for Extraction of Vegetable Oil and its Transesterification
4. Air-Conditioning Test-rig
5. Variable speed Centrifugal/Gear Pump Set-ups
6. Unsteady State Heat Transfer Set-up
7. Blower Test-rig

Study includes performance evaluation, calibration of measuring instrument/s and error analysis.It is also expected to conduct innovative experiment/s on the existing set-up with little modifications.

Modeling and Analysis in Thermal Engineering

MTE21	Modeling and Analysis in Thermal Engineering	PCC	3-1-0	4 Credits
Exam Scheme				
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Course Objectives: Objectives of this course are

1. To provide the sufficient knowledge to learn the thermal modeling of real engineering problems
2. To familiarize the students about the applications of fundamental laws and mathematics principles for thermal modeling
3. To understand the concept of optimization applied to engineering applications

Course Outcomes:

At the end of the course, student should be able to:

CO1	Attempt modeling real life systems of interest in order to predict its dynamic behavior.
CO2	Use simulation tools to determine dynamic response of system following external inputs.
CO3	Understand capabilities and limitations of various numerical and mathematical models.
CO4	Optimization of thermal systems, formulation, optimization methods.
CO5	Deep understanding on the governing equations for convection heat transfer; knowing the dimensionless parameters

Mapping of COs with POs:

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		1			2							
CO2	1	1		2								
CO3				1								
CO4	2			1	1							
CO5	1											

Course Contents

Unit I

Introduction: Engineering Design, design and analysis, Workable and optimum system, formulation Thermal systems, basic characteristics and analysis.

Unit II

Modeling of Thermal systems: Procedure of mathematical modeling, basic features of modeling, System and types of Model, characteristic of models, Curve fitting, exact fit, best fit.

Unit III

Modeling and analysis of thermal systems, including - thermodynamics, fluid mechanics, heat and mass transfer, refrigeration and air-conditioning, system components (heat exchangers, expansion devices, pumps, compressors, turbines, boilers).

Unit IV

Thermal system simulation: Sequential simulation, simultaneous simulation, successive substitution, Newton-Raphson method.

Unit V

Optimization of thermal systems, formulation, optimization methods; Lagrange Multipliers, Search Methods, Linear programming, Dynamic programming and geometric programming.

Unit VI

Develop methodologies for the design and optimization of thermal systems. A non-linear equation solver, Engineering Equation Solver (EES), Pinch technology: basic concepts, T-h, h-s diagrams, design of recovery system using pinch technology.

TEXTS / REFERENCES:

1. Yogesh Jaluria , *Design and Optimization of Thermal Systems* ,McGraw Hill Companies, Inc.
2. W.F.Stoecker: "*Design of Thermal Systems*", 3rd Ed., McGraw Hill,1989.
3. B.K.Hodge: "*Analysis and Design of Thermal Systems*", Prentice Hall Inc., 1990.
4. I.J.Nagrath&M.Gopal: "*Systems Modeling and Analysis*", Tata McGraw Hill.
5. D.J. Wide: "*Globally Optimal Design*", Wiley- Interscience, 1978.
6. R.F.Boehm, Design Analysis of Thermal systems, John Willey and son's
7. A. Bejan,M.moran, Thermal Design and Optimization, John Willey and son's

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Fluid Dynamics

MTE22	Fluid Dynamics	PCC	3-1-0	4 Credits
Exam Scheme				
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Course Objectives: Objectives of this course are

1. To provide the technical understanding of Fluid mechanics in the back ground of mathematics
2. To familiarize the students about the fluid dynamics and its applications to model the real life engineering problems
3. To apply the subject knowledge in the areas like CFD

Course Outcomes:

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

CO1	Understand and define basic fluid dynamic concept like continuum, surface forces, stress tensor and vector fields, Eulerian and langrangian flow.
CO2	Define the motions of fluid elements and derive continuity equation,stream function and velocity potential.
CO3	Derive and apply Navier-stokes equation to various types of flow systems.
CO4	Apply Boundary layer theory concept, and able to derive solutions by various numerical methods.
CO5	Describe and analyze the different flow, velocity correlation and universal velocity distribution.
CO6	Examine and numerical analysis of PDE and providing techniques for interpreting and analyzing the behavior of numerical schemes.

Mapping of COs with POs

PO's → CO's↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2											
CO2	1	1										
CO3	1											
CO4	1	1		2								
CO5	1	1										
CO6	1	1		2						1		

Note: 1- Means least contribution, 2- Means medium contribution, 3- Maximum contribution

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Course Contents

Unit I
Concept of continuum and definition of a fluid. Body and surface forces, stress tensor, Scalar and vector fields, Eulerian and Lagrangian approach.

Unit II
Motion of fluid element - translation, rotation and vorticity; strain rate tensor, continuity equation, stream function and velocity potential. Transport theorems, constitutive equations,
Unit III
Derivation of Navier Stokes equations for compressible flow. Exact solutions of Navier Stokes equations : plane Poiseuille flow and Couette flow, Hagen-Poiseuille flow, flow over a flat pate, cylinders and spherical bodies , Stoke's first and second problem, Hiemenz flow, flow near a rotating disk, flow in convergent- divergent channels. Slow viscous flow: Stokes and Oseen's approximation, theory of hydrodynamic lubrication.

Unit IV
Boundary layer: derivation, exact solutions, Non dimensionalization of Boundary layer equation, Blasius (similarity solution) , Falkner Skan, Von-karmon integral equation series solution and numerical solutions. Approximate methods. Momentum integral method.

Unit V
Turbulent flow: algebraic models, hydrodynamic stability, velocity correlations, Reynold's stresses, Prandtl's Mixing Length Theory, Karman's velocity defect law, universal velocity distribution, Plane and axi-symmetric jets, Two equation model(k-epsilon), large eddy simulation.

Unit VI
Compressible flow: 1D flow, speed of sound, variable c/s flow , converging-diverging nozzle, normal shock relation, past slender bodies, compressible boundary layer.
Computational fluid dynamics: Introduction, fundamentals of numerical analysis of partial differential equations (PDE).

TEXTS / REFERENCES:

1. F.M.White ,Fluid Mechanics, McGraw-Hill
2. K.Muralidhar and Bishwas, Advanced Engineering Fluid Mechanics, Alpha science international limited
3. Fox and McDonald, *Introduction to Fluid Mechanics*, J.H. Wiley and Sons.
4. S.M.Yahya, *Fundamentals of Compressible Flow*, Wiley Eastern Ltd.
5. H. Schlichting, *Boundary Layers Theory*, McGraw-Hill.
6. J.M.Robertson, *Hydrodynamics in Theory and Application*, Prentice Hall.
7. A.H.Shapiro, *The Dynamics and Thermodynamics of Compressible Fluid Flow*, Ronald.

Conservation of Energy in Buildings

MTE23A	Conservation of Energy in Buildings	PEC	3-0-0	3 Credits
Exam Scheme				
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks		Total 100 Marks

Course Objectives:

- Provide strategic leadership for the implementation of energy management in light of the "culture" of your organization
- Assess current organizational energy management capacity Plan actions to increase capacity
- Provide leadership for in-house assessment of energy use and identification of savings opportunities

Course Outcomes:

At the end of the course, student should be able to:

CO1	Identify and demonstrate the demand supply gap of energy in Indian scenario.
CO2	Carry out experiment and energy audit of an industry/Organization. Draw conclusion and suggest mitigations to that industry.
CO3	Draw the energy flow diagram of an industry and identify the energy wasted or a waste stream
CO4	Analyze and select appropriate energy conservation method to reduce the wastage of energy.
CO5	Evaluate the techno economic feasibility of the energy conservation technique adopted.

Mapping of COs with POs:

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2										
CO2	1	1	2	1	1	1	1	1			1	
CO3	1			1	1							
CO4	2	1				1						
CO5	2			1	1							

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Course Contents

Unit I
Introduction and a history of conservation of energy in buildings.

Unit II

Climates and buildings. Thermal properties and energy content of building materials. Embodied Energy, concept of green Building, LEED Rating etc.

Unit III
Windows design and daylight, Window shading, View factor and energy conservation. Alternative cooling solutions

Unit VI
Energy conservation techniques in Air-conditioning systems. Lighting (Dylighting and Electric lighting). passive and active methods of heating and cooling, Air-conditioning controls

Unit V
Estimation of building loads. Steady state method, Network method, Numerical method, Correlation's,

Unit VI
Computer packages such as V-Pro for carrying out thermal design of buildings and predicting performance.

TEXTS / REFERENCES:

1. M.S.Sodha, N.K.Bansal. P.K.Bansal. A.Kumar and M.A.S.Malik, *Solar PassiveBuilding, Science and Design,*Pergmon Press, 1986.
2. J.R.Williams, *Passive Solar Heating*, Ann Arbar Science, 1983.
3. R.W.Jones, J.D.Balcomb, C.E.Kosieqiez, G.S.Lazarus, R.D.McFarlandandW.O.Wray, *Passive Solar Design Handbook*, Vol. 3, Report of U.S. Department of Energy (DOE /CS-0127/3), 1982.
4. J.L.Threlkeld, *Thermal Environmental Engineering*, Prentice Hall, 1970.

Computational Fluid Dynamics

MTE23B	Computational Fluid Dynamics	PEC	3-0-0	3 Credits
Exam Scheme				
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Course Objectives:

1. To Understand the concept of fluid dynamics, CFD techniques, convergence criteria
2. To familiarize the students about the implementation of CFD in fluid mechanics and heat transfer problems
3. To understand the use of software based on CFD

Course Outcomes:

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

CO1	Identify applications of finite volume and finite element methods to solve Navier-Stokes equations.
CO2	Evaluate solution of aerodynamic flows. Appraise & compare current CFD software. Simplify flow problems and solve them exactly.
CO3	Design and setup flow problem properly within CFD context, performing solid using CAD package and producing grids via meshing tool.
CO4	Interpret both flow physics and mathematical properties of governing Navier-Stokes equations and define proper boundary conditions for solution.
CO5	Use CFD software to model relevant engineering flow problems. Analyse the CFD results. Compare with available data, and discuss the findings.

Mapping of COs with POs:

POs → Cos↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1										
CO2	1		2	3	1	1						
CO3	2	1	1	2	1		1					
CO4	1			1	1	1						
CO5			2	2	2	1				2		1

Course Contents

UNIT I
Introduction to CFD
Computational approach to Fluid Dynamics and its comparison with experimental and analytical methods, Basics of PDE: Elliptic, Parabolic and Hyperbolic Equations

UNIT II

Governing Equations

Review of Navier-Stokes Equation and simplified forms, Solution Methodology: FDM and FVM with special emphasis on FVM, Stability, Convergence and Accuracy.

UNIT III

Finite Volume Method

Domain discretization, types of mesh and quality of mesh, SIMPLE, pressure velocity coupling, Checkerboard pressure field and staggered grid approach.

UNIT IV

Geometry Modeling and Grid Generation

Practical aspects of computational modeling of flow domains, Grid Generation, Types of mesh and selection criteria, Mesh quality, Key parameters and their importance.

UNIT V

Methodology of CFDHT

Objectives and importance of CFDHT, CFDHT for Diffusion Equation, Convection Equation and Convection-Diffusion Equation.

UNIT VI

Solution of Navier-Stokes Equations for Incompressible Flows

Semi-Explicit and Semi-Implicit Algorithms for Staggered Grid System and Non Staggered Grid System of N-S Equations for Incompressible Flows.

Reference Books:

1. J. D. Anderson, Computational Fluid Dynamics-The Basics with Applications, Mcgraw Hill.
2. An Introduction to Computational Fluid Flow: The Finite Volume Method, by H.K. Versteeg and W. Malalasekera, Prentice Hall
3. Computational Methods for Fluid Dynamics by Ferziger and Peric, Springer Publication
4. Muralidhar K. and Sundararajan T., Computational Fluid Flow and Heat Transfer, Narosa Publishing House, New Delhi1995.
5. S. V. Patankar, Numerical Heat Transfer and Fluid Flow, T & F.
6. An Introduction to Computational Fluid Mechanics by Chuen-Yen Chow, Wiley Publication.

Advanced Refrigeration

MTE23C	Advanced Refrigeration	PEC	3-0-0	3 Credits
Exam Scheme				
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks		Total 100 Marks

Course Objectives: Objectives of this course are

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

Pre requisite: Refrigeration and Air-conditioning

Course Outcomes:

At the end of the course, student should be able to:

CO1	Formulate and solve vapor compression refrigeration and multi-stage vapor compression systems.
CO2	Study and identify various types of refrigerants and their properties., such as zeotropic, azeotropic etc.,
CO3	Illustrate Nomenclature, Refrigerants, alternative refrigerants, CFC/HCFC phase-out regulations, action with lubricating oil, retrofitting, refrigerant blends, effects on refrigeration components.
CO4	Design and analyze vapor absorption system
CO5	select refrigerant control techniques,and do piping designing for refrigeration plant

Mapping of COs with POs:

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1										
CO2	1											
CO3	1											1
CO4						1						1
CO5	2	1		1		2						

Course Contents

Unit I

Vapor compression refrigeration, actual cycle, second law efficiency, multistage compression with inter-cooling, Multi-evaporator systems, Cascade systems.

Unit II
Performance characteristics and capacity control of reciprocating and centrifugal compressors, screw compressor and scroll compressor, compressor motor selection

Unit III
Design, selection of evaporators, condensers, system balance, control systems.

Unit IV
History, Nomenclature, Refrigerants, alternative refrigerants, CFC/HCFC phase-out regulations, action with lubricating oil, retrofitting, refrigerant blends, effects on refrigeration components. Thermoelectric and nonconventional refrigeration systems, adiabatic de-magnetization.

Unit V
Vapor absorption refrigeration, Li-Br and aqua ammonia system, calculation of mass flow rate and system performance, energy balance, controls, analysis of rectifier and analyzer, single effect and double effect systems, vapor transformer.

Unit VI
Refrigeration controls, Flow controls, Temperature controls, Expansion devices: design and selection, refrigeration system piping design.

TEXTS / REFERENCES:

1. Stoecker W. F. and Jones J. P.,*Principles of Refrigeration and air-conditioning*, McGraw Hill
2. Arora C. P., *Refrigeration and air-conditioning*, Tata McGraw Hill.
3. Gosney W. B., *Principles of refrigeration*, Cambridge University Press.
4. Stoecker W. F., *H. B. of Industrial refrigeration*, McGraw Hill Companies, Inc.
5. Dossat R. J., Principles of Refrigeration, Pearson Education
6. ASHRAE H. B. – Refrigeration
7. ASHARAE H. B. – Fundamental
8. Edward Pita, Air Conditioning Principles and Systems,Prentice Hall

Design of Heat Exchangers

MTE23D	Design of Heat Exchanger	PEC	3-0-0	3 Credits
Exam Scheme				
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Course Objectives: Objectives of this course are

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

Course Outcomes:

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

CO1	Demonstrate and of heat exchanger design methodology, and design considerations
CO2	Analyze performance of Heat exchanger by applying basic design theory.
CO3	Design and conduct experiment on one from double pipe, shell and tube, tube fin, plate type and plate-fin heat exchanger.
CO4	Demonstrate selection criteria of HEX and conduct an independent research to suggest suitable HEX.
CO5	Model and illustrate heat exchanger based on I-law and irreversibility.
CO6	Study and analyze losses in HEX, and upcoming advancements.

Mapping of COs with POs:

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1							1			
CO2	1	1										
CO3			2						2			
CO4	2	1					1		1			
CO5	1											
CO6	1			1	1							

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Course Contents

Unit I

Introduction: Classification, overview of heat exchanger design methodology, Design specifications, thermo hydraulic design, and other considerations.

Unit II

Basic design theory: LMTD method, ε-NTU method, P-NTU method, ψ-P method and P1-P2 method.

Unit III

Heat exchanger design procedures: Design of double pipe, shell and tube, tube fin, plate type and plate-fin heat exchanger, Design of cryogenic heat exchangers.

Unit IV

Selection of heat exchangers: selection criteria, general selection guidelines of shell and tube heat exchanger, plate type heat exchanger.

Unit V

Thermodynamic modeling and analysis: modeling of heat exchanger based on I-law and Irreversibility.

Unit VI

Header design: Flow maldistribution, fouling and corrosion, advances in heat exchangers.

TEXTS / REFERENCES:

1. R.K.Shah and DeusanP.Sekulic, *Fundamentals of heat exchanger design*, 2003, John Willeyand Sons.
2. S. Kakac, Heat *Exchangers – Thermal Hydraulic Fundamentals and Design*, Hemisphere, Mc Graw-Hill.
3. D. Q. Kern and A. D. Kraus; *Extended Surface Heat transfer*, McGraw-Hill.
4. D. Q. Kern, Process Heat Transfer, McGraw-Hill.
5. W. M. Kays and A. C. London, *Compact Heat Exchangers*, McGraw-Hill.

Alternative Fuels for IC Engine

MTE23E	Alternative Fuels for IC Engine	Elective III	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks		Total 100 Marks

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

CO1	Demonstrate Structure of petroleum, Refining process, Products of refining process, Select suitable fuels for use in SI engines. Understand various performances rating in SI engines.
CO2	Illustrate properties of petroleum products and classify them on their characteristic.
CO3	Describe and analyze Need for alternative fuels such as Ethanol, Methanol, LPG, CNG, Hydrogen and their manufacturing procedure.
CO4	calculate and estimate performance and emission characteristics of alternative fuels
CO5	Analyze environmental effects of combustion of various fuels, suggest modification in their usage.

Mapping of course outcomes with program outcomes

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2										
CO2		1										
CO3	1	1		1	1							
CO4			1	1								
CO5	1	1			1	1						

Course Contents

Unit I:

Fuels: Introduction, Structure of petroleum, Refining process, Products of refining process, Fuels for spark ignition, Knock rating of SI engine fuels, Octane number requirement, Diesel fuels and Numericals.

Unit II:

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

Unit III:

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

Unit IV:

Single Fuel Engines: Properties of alternative fuels, use of alternative fuels in SI engines, Engine modifications required, Performance and emission characteristics of alternative fuels in SI mode of operation v/s gasoline operation.

Unit V:

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

Biodiesels: What are biodiesels, Need of biodiesels, Properties of biodiesels V/s petro diesel, Performance and emission characteristics of biodiesels v/s Petro diesel operation.

Unit VI:

Availability: Suitability & Future prospects of these gaseous fuels in Indian context.

Environmental pollution with conventional and alternate fuels, Pollution control methods and packages.

Texts / Reference Books:

1. R.P Sharma & M.L.Mathur: "A Course in Internal Combustion Engines", D.Rai& Sons.
2. O.P. Gupta: "Elements of Fuels, Furnaces & Refractories", Khanna Publishers, 2000.
3. Domkundwar V.M.: "Internal Combustion Engines", I Edition, Dhanpat Rai & Co., 1999
4. John B. Heywood: "Internal Combustion Engines Fundamentals", McGraw Hill International Edition,
5. Osamu Hirao& Richard Pefley: "Present and Future Automotive Fuels", Wiley Interscience Publication. NY. 1988.

Boundary Layer Theory

MTE23F	Boundary Layer Theory	PEC	3-0-0	3 Credits
Exam Scheme				
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Course Objectives:

1. To Understand the concept of fluid mechanics and physics of boundary layer
2. To familiarize the students about the boundary layer formation over the stream lined body, bluff body and thickness measurement
3. To understand the real life application of BL

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

CO1	Evaluate exact solution of Navier-stokes equation in boundary layer that exhibit small viscosity by applying mathematical, Numerical techniques.
CO2	Demonstrate boundary-layer equations in the spirit of Prandtl, Prandtl boundary-layer equations in two dimensions deduced by order-of-magnitude arguments, skin friction drag.
CO3	calculate and solve ODE's for classical boundary-layer equations of Prandtl
CO4	Formulate and develop Exact solutions of the classical boundary-layer equations,
CO5	Analyze occurrence in steady flows, and at rear stagnation point of impulsively started cylinder, Goldsten singularity.

Mapping of course outcomes with program outcomes

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		1		1		1						
CO2		2										
CO3	1			2		1						
CO4		1										
CO5	1			2								

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Course Contents

Unit I

Exact solutions of the Navier-Stokes equation that exhibit a boundary layer at small values of the viscosity.

Unit II

The boundary-layer equations in the spirit of Prandtl. Scaling, non-depersonalization and Reynolds number. Limitations of potential flow past a cylinder. Prandtl boundary-layer equations in two dimensions deduced by order-of-magnitude arguments. Blasius solutions, displacement thickness, skin friction, drag.

Unit III

Introduction to perturbation theory. Regular and singular perturbations. Examples from algebraic equations and ordinary differential equations. The classical boundary-layer equations of Prandtl as the leading term in a matched asymptotic expansion.

Unit IV

Exact solutions of the classical boundary-layer equations, examples. A selection of those below .Flow past a wedge, Falkner Skan. Far wake of a flat plate. Two-dimensional jet. Lock'mixing layer. Prandtl transformation. Axisymmetric flows: Mangler's transformation. Splitdisc Ekman layer problems: Stewartson layers. Glauert wall jet.

Unit V

Separation in adverse pressure gradients. Concept of and occurrence in steady flows, and at rear stagnation point of impulsively started cylinder. Form of skin friction near separation point: Goldstein singularity.

Unit VI

Introduction to interactive boundary layers. Goldstein near wake. Trailing-edge triple deck.

TEXTS / REFERENCES:

1. Batchelor, G. K. *An Introduction to Fluid Mechanics*. CUP.
2. Curle, N. *The Laminar Boundary-Layer equations*. OUP.
3. Curle, N. & Davies, H. J. *Modern Fluid Dynamics*, VolI. Incompressible Flow.
4. Hinch, E. J., *Perturbation Methods*, CUP.
5. H.Schlichting, *Boundary Layer Theory*. McGraw Hill.
6. Van Dyke, M., *Perturbation Methods in Fluid Mechanics*. Parabolic Press.
7. Rosenhead, L. (ed). *Laminar Boundary Layers*. OUP.
8. Nayfeh, A. *Introduction to Perturbation Techniques*.
9. Sobey, I. J. *Introduction to Interactive Boundary Layer Theory OUP*.

JET AND ROCKET PROPULSION

MTE23G	Jet and Rocket Propulsion	PEC	3-0-0	3 Credits
Exam Scheme				
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks		Total 100 Marks

Course Objectives:

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

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

CO1	Apply knowledge of features and capabilities of chemical and non-chemical rocket propulsion systems.
CO2	Calculate the design thrust and overall efficiency of turbojet and turbofan engines, with and without afterburners, from given component performance.
CO3	Calculate the specific impulse and mass flow for a rocket engine with the fluid considered as an ideal gas with constant specific heats.
CO4	Estimate the specific impulse and mass flow for a rocket engine accounting for chemical reaction and non-constant specific heats.
CO5	Estimate the heat transfer rates in rocket nozzles and in aero-engine turbine components.
CO6	Design simple rocket propulsive system.

Mapping of course outcomes with program outcomes

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1											
CO2	2		2			1						
CO3	1		2	2				1		1		
CO4		2					1					
CO5	1											1
CO6	1	2	2	1	1				2			2

Course Content

Unit- I

Velocity triangles; compressor performance maps, Compressor blading; design; multi-staging, Turbines; stage characteristics; degree of reaction, mass flow limits; blade temperature. Turbine cooling; general trends and systems; internal cooling, Film cooling; thermal stresses; impingement cooling; how to do cooling design, Compressor-turbine matching; gas generators, Engine structures; centrifugal stresses; engine arrangements, Critical speeds and vibration, Combustors; afterburners.

Unit II

Jet climb & acceleration, calculation of drag and thrust, optimum exhaust velocity, Air breathing and non-air breathing engines, aircraft gas turbine engine, cycles analysis of ideal and real engines, components performance-intake, combustor, nozzle, turbomachinery, etc. limitations of jet engines, Rocket equation; optimum acceleration, Rocket staging.

UnitIII

Turbojet, turboprop, turbofan engines, ramjet and pulsejet, design parameters; performance parameters like thrust, propulsive efficiency. Models for rocket engines; Inlets or diffusers, Exhaust nozzles, Compressors and fans.

Unit IV

Modeling of thermal rocket engines; fuels, fuels arrangement, Types of nozzles; connection of flow to nozzle shape, control of mass flow, Modeling of rocket nozzles; effects of nozzle area ratio.

Unit V

Jet engine and rocket structures, Rocket casing design; structural modeling, Heat transfer and cooling arrangement, Ablative cooling, Thrust vectoring; mass estimates.

Unit VI

Chemical Rockets, types of propellants and their properties, injectors, thrust chamber, burning rate; Solid propellant gas generators; stability; grain designs; Cryogenic propellant, combustion phenomena, thrust vector control, ignition and inhibitors. Basics of Electrical and Nuclear rockets. Pollutant; motivations for control; formation; strategies for reduction, Aircraft engine noise: principles; regulations, Jet noise, turbomachinery noise, Rotordynamics of the jet engine.

References:

1. Kerrebrock, J. L. *Aircraft Engines and Gas Turbines*.2nd ed. MIT Press, 1992.
2. Sutton, G. P., and O. Biblarz. *Rocket Propulsion Elements*.7th ed. Wiley Interscience, 2000.
3. J Mattingly, Elements of Gas Turbine Propulsion, McGraw-Hill Publications, 1996.
4. G.P. Sutton and O. Biblarz, Rocket Propulsion Elements, John Wiley & Sons, 2001.
5. G.C.Oates, Aerothermodynamics of Gas Turbine and Rocket Propulsion, AIAA, New York, 1988.
6. N.A.Cumpsty, Jet Propulsion, Cambridge University Press, 2000.

7. P G Hill and C R Peterson, Mechanics and Thermodynamics of Propulsion, Addison Wesley, 1965.
8. M J Zucrow, Aircraft and Missile Propulsion (Vol.I and II), John Wiley, 1958.
9. W WBathie, Fundamentals of Gas Turbines, John Wiley, 1996.
10. H Cohen, G F C Rogers and H I H Saravanamuttoo, Gas Turbine Theory, Addison Wesley, 1998.

Steam and Gas Turbines

MTE24A	Steam and Gas Turbines	PEC	3-0-0	3 Credits
Exam Scheme				
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Course Objectives:

1. To provide the sufficient knowledge of working, construction and control of ST and GT
2. To familiarize the students about the industrial applications of ST and GT
3. To understand the analysis of GT and ST employing real life data

Course Outcomes:

At the end of the course, student should be able to:

CO1	Illustrate properties of Steam, Draw P-V, T-s, H-s(Mollier) diagrams for steam, Describe Theoretical steam turbine cycle.
CO2	Demonstrate and analyze vortex flow, energy lines and reheat factors of steam turbines. Solve problems of finding performance steam turbine power plant.
CO3	Demonstrate simple Brayton cycle for gas turbine analyze its performance on computer simulation, suggest suitable modification and then analyze it.
CO4	Study and apply various Performance Improvement Techniques in steam and gas Turbines
CO5	Design and suggest and analyze cooling accessories and protective material for steam turbine.

Mapping of COs with POs:

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1										
CO2		2										
CO3	1	1		3	1							
CO4	2	1			2	1						
CO5	1	1		1	1							

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Course Contents

Unit I

Introduction, properties of steam, steam quality, Theoretical steam turbine cycle. The flow of steam through Impulse and Impulse–Reaction turbine blades, compounding of steam turbine.

Unit II

Vortex flow in steam turbines, Energy lines, State point locus, Reheat factor and Design procedure. Governing and performance of steam turbine, Effect of operating variables on thermal efficiency.

Unit III
Steam nozzles, Turbine Blade-Design, Selection of blade profile, blade cooling techniques, material, protective coating.

Unit IV
Gas turbine Introduction, simple open cycle gas turbine, Actual Brayton cycle, Means of Improving the efficiency and the specific output of simple cycle, Regeneration, Reheat, Intercooling,

Unit V
closed-cycle gas turbine,turbine velocity diagram and work done, Performance improvement, Effect of operating variables on thermal efficiency.

Unit VI
fuel supply techniques and control, Combuster design, Lubrication, Maintenance and trouble shooting.

TEXTS / REFERENCES:

1. W.J.Kearton, *Steam Turbine Theory and Practice*, ELBS.
2. R.Yadav, *Steam and Gas Turbine*, Central Publishing Home, Allahabad.
3. Jack D. Mattingly., *Elements of Gas Turbine propulsion*, McGraw – Hill Pub.,
4. Cohen Rogers, *Gas Turbine Theory*, Longman Publishing.
5. V Ganesan: “*Gas Turbines*”, 2002

Mechatronics

ME-XX24A	Mechatronics	PEC	3-0-0	3 Credits
Exam Scheme				
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Course Objectives:

- To develop an ability to identify, formulate, and solve engineering problems.
- To develop an ability to design a system, component, or process to meet desired needs within realistic constraints.
- To develop an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Course Outcomes:

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

CO1	Define sensor, transducer and understand the applications of different sensors and transducers
CO2	Explain the signal conditioning and data representation techniques
CO3	Design pneumatic and hydraulic circuits for a given application
CO4	Write a PLC program using Ladder logic for a given application
CO5	Understand applications of microprocessor and micro controller
CO6	Analyze PI, PD and PID controllers for a given application

Mapping of COs with POs:

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	3	2				2	1		1
CO2	3	2			3	3	2				1	3
CO3	1	1		3	3	2	1		3		1	3
CO4	3	3	1	1	3		1	1	1			
CO5	3			1	3	2	3					2
CO6		3	3		3	3	1	1	3			2

Course Content

Unit I

Introduction to Mechatronic systems, elements, advantages and practical examples of Mechatronic systems.

Sensors and Transducers:

Various types of sensors and transducers used in Mechatronic system such as pressure sensors, temperature sensors, velocity sensors, Acceleration sensors, proximity sensors, position sensors, force sensors, Optical encoders, Capacitive level sensor, tuctile sensors, Selection of sensors.

Unit II

Signal Conditioning and Data Representation

Types of electronic signals, Need for signal processing, Operational amplifiers: Types, classification and applications, Opto-isolators, Protection devices, Analogue to Digital and Digital to Analog Converters, Interfacing devices, Electro-magnetic Relays, Data representation systems, Displays, Seven segment displays, LCD displays, Printers, Data loggers, Data Acquisition Cards/Systems

Unit III

Electrical Drives: Types of Electrical Motors, AC and DC motors, DC servomotors, Stepper motors, linear motors, etc.

Pneumatics and Hydraulics

Components of Pneumatic systems, actuators, direction control valves, pneumatic air preparation, FRL unit, methods of actuation of valves, Sequencing of Pneumatic cylinders using Cascade and shift register methods. Electro-pneumatic valves, Electro- pneumatic circuits using single and double solenoid methods.

Hydraulic cylinders, design of cylinder, Design of Piston and piston rod, Valves, poppet valve, house pipes and design of tubing, Meter-in and Meter-out circuits.

Unit IV

Microprocessor and Microcontroller

8085 microprocessor, architecture, various types of registers and their functions in 8085µP, Instruction sets, interfacing, applications. 8081 microcontroller, architecture, Instruction sets, various pins and their functions interfacing, applications.

Programmable Logic Controller

Introduction, Architecture, Types of inputs/outputs, Specifications, guidelines for
Selection of PLCs, Programming: Ladder logic and FBD

Unit V

Control Systems

Open and closed loop system; block diagram manipulation/reduction, Transfer function, modeling of Mechanical Systems using spring, Dashpot and Masse quivalence.

Unit VI

Stability of Systems

On/Off controller, Proportional Control, Integral control, Derivative Control; PI, PD and PID Controllers, Introduction to control using state variable system models, Bode Plots and stability criteria.

Text Books

1. HMT Limited, *Mechatronics, Tata McGraw*-Hill, 1998.
2. Bolton,W., *Mechatronics; Electronic Control System in Mechanical Engineering*, Pearson Education Asia, 1999.
3. Raven, *Automatic Control Engineering, McGraw-Hill, NewYork,1986*

Cryogenic Engineering

MTE24B	Cryogenic Engineering	PEC	3-0-0	3 Credits
Exam Scheme				
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Course Objectives:

- To cover the basic principles of cryogenic engineering.
- To develop an intuitive understanding of cryogenics for the student who are interested to study the science technology of low temperatures.

Course Outcomes:

At the end of the course, student should be able to:

CO1	Demonstrate and identify role of cryogenics in the industrial applications.
CO2	Describe mechanical, thermal, thermo-electric properties of cryogenic fluids.
CO3	Illustrate Ideal separation, properties of mixtures, Rectifiers column, separation of air, purification.
CO4	List and give details about various types of cryogenic refrigeration system, such as J-T Refrigeration systems, Philips refrigerator, Vuilleumier refrigerator, Solve refrigerator, G-M refrigerator
CO5	Study and describe Insulation and storage systems in cryogenic engineering

Mapping of COs with POs:

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1										
CO2	1	2										
CO3	1	2		1	1							
CO4	1	1		1	1	1						
CO5	1	2			1							

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Course Contents

Unit 1

Introduction:

Industrial applications, research and development, properties of cryogenic fluids-oxygen, nitrogen, air, hydrogen and helium.

Behaviour of Structural Materials at Cryogenic temperature:

Mechanical properties, thermal properties, thermoelectric properties.

Unit 2

Liquefaction of Cryogenic Gases:

Inversion Temperature, Liquefaction Performance Parameters, Ideal cycle, liquefaction of air, Hydrogen and helium, critical components of liquefiers, efficiency, Cryogenic heat exchangers.

Separation of Gases:
Ideal separation, properties of mixtures, Rectifiers column, separation of air, purification.

Unit 3
Cryogenic Refrigeration Systems:
Ideal refrigeration systems, J-T Refrigeration systems, Philips refrigerator, Vuilleumier refrigerator, Solvey refrigerator, G-M regrogerator.

Unit 4
Insulation:
Vacuum insulation, fibrous materials, Solid foams, Gas filled power, comparison, critical thickness.

Unit 5
Storage:
Size and shape of vessel, portable commercial containers, large stationary container, power, transport, storage system, Liquid level indicators.

Unit 6
Transfer of Liquefied Gases:
Two phase flow transfer through insulated and uninsulated lines, cryogenic pumps and valves.

TEXTS:

1. R. F. Barron, Cryogenic Systems, Oxford University Press, 1985.
2. *Advanced Cryogenic Engineering*, Proceedings of Cryogenic Engineering Conference, Vol 1-145, Plenum press, New York, 1968.

Combustion Engineering

MTE24C	Combustion Engineering (Elective-I)	PEC	3-0-0	3 Credits
Exam Scheme				
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Course Objectives: Objectives of this course are

1. To provide the sufficient knowledge of combustion engineering apply in real engineering problems
2. To familiarize the students about the combustion process in the back ground of IC engine
3. To understand the simulation of combustion process

Course Outcomes:

At the end of the course, student should be able to:

CO1	Understand and recognize System Conservation Laws, Reynolds Transport Theorem, Governing 3D Partial Differential Equations etc.,
CO2	Formulate and model, General Probability Density Function, Turbulent Pre-mixed and non pre-mixed flames.
CO3	knowledge of fuel thermo-chemistry and fuel quality effects on emissions, engine technologies, engine combustion-related emissions and control technologies
CO4	Extend their knowledge of fuels and engines to different situations of engineering context and professional practice.
CO5	Demonstrate the ability to engage in life-long learning.

Mapping of COs with POs:

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2											
CO2		2										
CO3	1		1		1		1					
CO4						1			1			
CO5												2

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Course Contents

Unit I

Review of energy sources and fossil fuels, role of combustion in energy conservation, comprehensive treatment of combustion principles and their applications.

Unit II:

Thermochemistry: Stoichiometry and combustion reactions**,** Enthalpy of formation**,** Calculation of excess air**,** Adiabatic flame temperature**,** Chemical thermodynamics and chemical kinetics, Conservation equations for multi-component systems, System Conservation Laws, Reynolds Transport Theorem, Governing 3D Partial Differential Equations, Shvab-Zeldovich Coupling Functions and Mixture Fraction.

Unit III

Premixed systems detonation and deflagration, laminar flames,1D propagating flame and flame speed Quenching, flammability, ignition and blow off, effects of different variables on burning velocity, methods for measuring burning velocity, flammability limits, ignition and quenching, detonations, their propagation and structure, flame stability.

Laminar Non-premixed (Diffusion) Flames, laminar diffusion flame jet, Jet flames and the Burke-Schumann Solution, Soot Formation, Counter-flow Flames.

Unit IV

Turbulent pre-mixed flames, turbulent flames, turbulent combustion, chemical effects on turbulence, transition from laminar to turbulent diffusion flames.

Non-premixed systems: Flamelet Modeling Approaches, General Probability Density Function (PDF) Formulations

Unit V

Droplet Combustion, Droplet Evaporation, Droplet Combustion, Simple 1-D Analysis for Multiphase Flows

Unit VI

Combustion of solids: drying, devolatilization and char combustion, Practical aspects of coal combustion. Pollution and environment**.** Formation and control of pollution in flames, engineering applications; Combustion processes in SI Engines and C.I. Engines, Gas turbine combustors, fluidized bed combustors, Design of burners and Combustion chambers.

TEXTS/REFERENCES:

1. N.A.Chigier, Energy, *Combustion and Environment*, McGraw-Hill Co, New York, 1981.
2. Glassman, *Combustion*, Academic Press, New York, 1977
3. A.MurthyKanury, *Introduction to Combustion Phenomena*, Gordon and Breach, New York, 1975.
4. S.P.Sharma and Chander Mohan, *Fuels and Combustion*, Tata McGraw-Hill, 1984.
5. K. K. Kuo, *Principles of Combustion*, (excellent more advanced reference)
6. *Combustion – Physical and Chemical Fundamentals*, *Modeling and Simulation, Experiments,*
7. J. Warnatz, U. Mass and R. W. Dibble, *Pollutant Formation*, by (excellent more advanced reference)
8. F. Williams, *Combustion Theory* (a classic - more mathematical treatment)
9. S.R. Turns , Introduction to combustion, Tata McGraw-Hill
10. N. Peters ,*Turbulent Combustion* (a nice up-to-date summary of the state-of-the-art on
11. turbulent combustion modeling for gas phase systems)

Nanotechnology

MMECH24C	Nano Technology	PEC	3-0-0	3 Credits
Exam Scheme				
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Course Objectives:

1. To Understand the concept of nano technology and its importance in real engineering applications
2. To familiarize the students about the use of nano technology in industrial world
3. To understand the physics of nana technology

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

CO1	Demonstrate the understanding of length scales concepts, nanostructures and nanotechnology.
CO2	Identify and to compare various synthesis and characterization techniques involved in Nanotechnology.
CO3	Define and interpret the interactions at molecular scale.
CO4	Evaluate and analyze the mechanical properties of bulk nano-structured metals and alloys, nano-composites and carbon nanotubes.
CO5	Compare and analyze the effects of using nanoparticles over conventional methods.

Mapping of course outcomes with program outcomes

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1				2	1				1	
CO2		2					2				1	
CO3	1	1	1		2				2	1		1
CO4	1	1				2	1				1	
CO5	1	1	1		2				2	1		1

Course Contents:

Unit I

Scientific Revolutions

Types of Nanotechnology and Nano machines: the Hybrid nanomaterial. Multiscale hierarchical structures built out of Nano sized building blocks (nano to macro).Nanomaterials in Nature: Nacre, Gecko, Teeth. Periodic table, Atomic Structure, Molecules and phases, Energy, Molecular and atomic size, Surfaces and dimensional space: top down and bottom up.

Unit II

Forces between Atoms and Molecules

Particles and grain boundaries, strong Intermolecular forces, Electrostatic and Vander Waals forces between surfaces, similarities and differences between intermolecular and inter particle forces covalent and coulomb interactions, interaction polar molecules, Thermodynamics of self-assembly.

Unit III

Opportunity at the Nano Scale

Length and time scale in structures, energy landscapes, Inter dynamic aspects of inter molecular forces, Evolution of band structure and Fermi surface.

Unit IV

Quantum dots – Nano wires – Nano tubes - 2D and 3D films - Nano and mesopores, micelles, bilayer, vesicles – bionano machines – biological membranes.

Unit V

Influence of NanoStructuring

Influence of Nano structuring on mechanical, optical, electronic, magnetic and chemical properties-gram size effects on strength of metals- optical properties of quantum dots.

Unit VI

Quantum wires - electronic transport in quantum wires and carbon nano-tubes - magnetic behavior of single domain particles and nanostructures – surface chemistry of Tailored monolayer – self assembling.

Texts/References:

1. C. C. Koch, "Nanostructured materials: Processing, Properties and Potential Applications", Noyes Publications, 2002.
2. C. C. Koch, I. A. Ovidko, S. Seal and S. Veprek, "Structural Nano crystalline Materials: Fundamentals & Applications", Cambridge University Press, 2011.

Numerical Heat Transfer

MTE24D	Numerical Heat Transfer	PEC	3-0-0	3 Credits
Exam Scheme				
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Pre-Requisites: Heat Transfer

Course Objectives:

1. To Understand the concept of heat transfer and numerical techniques applied to heat transfer
2. To familiarize the students about the relation of numerical heat transfer and CFD
3. To understand the application of NHT in real life problem

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

CO1	Learn the concept of Numerical Heat Transfer and its application
CO2	Explain boundary conditions and partial differential equations and formulation
CO3	Analysis the conduction problems using Numerical technique
CO4	Learn the converge methodology and techniques
CO5	Write programme based 1-D and 2-D conduction problem using NHT

Mapping of COs with POs:

POs→ COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		1			1	2	1				
CO2	3	1										
CO3	3	3	1					1				
CO4	3	3	1		2			1				
CO5				3	3	1	1	2				2

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Course Contents:

Unit 1:

Introduction

Basic approach in solving a problem by Numerical Methods, Finite difference method, Method of discretization, control volume approach, Numerical error, Grid independence test.

Unit 2:

Partial Differential Equations

Classification of PDEs,Elliptic, Parabolic and Hyperbolic Equations, Initial and Boundary conditions, Initial and boundary value problems.

Unit 3:

Numerical Methods for Conduction Heat Transfer (Part 1)

Application of heat conduction, steady and unsteady heat conduction, Dimensionality in conduction, Basic approach in Numerical Heat conduction, one dimensional steady state problem.

Unit 4:

Numerical Methods for Conduction Heat Transfer (Part 2)

Two dimensional problems, Transient one dimensional problem, Eular, crank – Nicholson and pure implicit method, stability.

Unit 5:

Numerical Methods for Incompressible Fluid Flow

Introduction, Governing equations, Navier Stokes Equations, Stream function velocity method, general algorithm inviscid flow.

Unit 6:

Numerical Methods for Convection Heat Transfer

Introduction, Convection diffusion, Thermal boundary layer flow, transient free convection.

Texts:

1. P. S.Ghoshdastidar, "Computer Simulation of Flow and heat transfer", Tata McGraw Hill Publications, New Delhi.
2. SuhasV.Patankar, "Numerical Heat Transfer and Fluid Flow", Tata McGraw Hill Book Company.
3. Varsteeg, Malalasekera, "An introduction to Computational Fluid Dynamics The finite volume method", Pearson Prentice hall.

References:

1. M. NecatiOzisik, "Finite Difference Methods in Heat transfer", CRC Press.
2. D. A. Anderson, J. C. Tannehill, R. H. Pletcher, "Computational Fluid Dynamics and Heat transfer", Hemisphere Publishing.

Biomass Energy

<table>
<tr><td>MTE24E</td><td>Biomass Energy</td><td>PEC</td><td>3-0-0</td><td>3 Credits</td></tr>
<tr><td colspan="5">Exam Scheme</td></tr>
</table>

<table>
<tr><td>Mid Sem Test
20 Marks</td><td>Continuous Assessment
20 Marks</td><td>End-Sem Exam
60 Marks</td><td>Total
100 Marks</td></tr>
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Course Objectives:

1. To Understand the concept of Biomass its importance, availability, and energy conversion process
2. To familiarize the students about the biomass systems design
3. To understand the industrial applications of Biomass systems through real life problems

Course Outcomes:

CO1	Illustrate relevance of biomass as energy source, enumerate advantages and disadvantages of biomass resources.
CO2	Survey and identify wasteland in India, suggest suitable biomass resource management.
CO3	Interpret biomass conversion processes, design gasification system and identify its use in SI and CI engines and analyze its performance.
CO4	Conduct an experiment and calculate load capacity, efficiency and identify maintenance, troubleshooting and exhaust emission problems.
CO5	Design and construct down draft gasifier, its Cooling–cleaning systems and Performance evaluation of a Down draft gasifier.

Mapping of COs with POs:

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2										
CO2	1		2		1	1		1				
CO3	1	1			2							
CO4			2	2	1	1					1	
CO5	2	1		1		1						

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Course Contents

Unit I

Introduction: Relevance of biomass as an energy source, Biomass Resources, Cultivated biomass resources, Water-to-biomass resources, Advantages associated with biomass resources, Availability of biomass for energy generation.

Unit II

Energy plantation: Concept, Objectives and advantages.

Wasteland development: Extent of water lands in India, Nature of waste lands.

Unit III

Biomass Conversion Processes: Combustion, Biochemical and Thermo chemical.

Gasification: Fuels for gasification, Properties of biomass - size, size distribution, bulk density, volatile matter, ash and ultimate analysis.Air gasification in a down draft gasifier, Types of gasifiers, Gasifier engine system, Use of producer gas in SI & CI engines, Reasons for decorating, Problems associated with gasifier engine system and its efficiency.

Unit VI

Design of a Down draft gasifier

Cooling–cleaning systems**M**Performance evaluation of a Down draft gasifier.

Unit V

Performance of Dual Fuel Engine: Power capacity, Diesel substitution, Thermal efficiency, Smoothness of operation, Load following capability, Maintenance and durability, Exhaust emissions.

Unit VI

Bio-conversion Process: The process, Types of biogas plants, Design of biogas plants, Factors affecting gas generation rate, Biogas engine for water pumping and electric power generation applications, Government programmes,

Wood fuelled Cooks stoves, Effects of various stove parameters, Effects of various stove components, Current versions of improved stoves, Efficiency of stoves, Utilization of biomass based fuels for thermal and shaft power applications.

TEXTS / REFERENCES:

1. T.B.Reed: "*Biomass Gasification Principles and Technology*", Noyes Data Corporation,Energy Technology Review, No.67, U.S.A., 1981.
2. P Vimal& M S Bhatt: "*Wood Energy Systems*", K L Publications, New Delhi – 1989
3. S Rao& B BParulkar: "*Energy Technology*" Khanna Publishers Delhi – 1999
4. A.Kaupp and J.R.Goss: "*State of Art Report for small scale Gas Producer Engine Systems*", FriedrVieweg&SohnVerlags, Gmbh, Braunschweig, 1984

Power Plant Practice and Control

MTE24F	Power Plant Practice and Control	PEC	3-0-0	3 Credits
Exam Scheme				
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Course Outcomes: At the end of the program, the student will be able to

CO1	Understand merits and demerits of various power plant and Criteria for selection of power plant and economics
CO2	Understand various safety devices and controlling devices for power plant
CO3	Comparison of various power plant on efficiencies, working performance, and characteristics
CO4	Plan and design the experimental investigations efficiently and effectively
CO5	Practice statistical software to achieve robust design of experiments.

Mapping of course outcomes with program outcomes

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1											
CO2		1										
CO3		1	1									
CO4						1						
CO5				1				1				

Course Contents

Unit I

Introduction: Energy reserves and Energy utilization in the world, Electrical power Generation & consumption in India. Types of power plants, merits and demerits, Criteria for selection of power plant. Power Plant Economics.

Hydro Electric Power Plants: Rainfall and run-off measurements and plotting of various curves for estimating stream flow and size of reservoir, power plants design, construction and operation of different components of hydro-electric power plants, site selection, comparison with other types of power plants.

Unit II

Steam Power Plant: Layout, Super Heaters, Reheaters, Condensers, Economizers and Feed Water heaters, Operation and performance, Rankine cycle with Superheat, Reheat and

Regeneration. Super critical boilers,Fluidized Bed combustion boiler - Advantages, Waste heat Recovery boilers, Co-generation Power Plant, Emissions and their controls.

Unit III

Nuclear Power Plant: Overview of Nuclear Power Plant, Nuclear physics Radio activity-fission process Reaction Rates, diffusion theory and Critical heat flux -Nuclear Power Reactors, different types, advantages and limitations, Materials used for Reactors. Hazards in nuclear power plant, remedial measures, safety precautions, methods of waste disposal, different form of waste from power plant.

Unit IV

Gas Turbine: Layout of Gas Turbine, Basic Gas turbine cycle, cycle improvements, Intercoolers, Reheaters and regenerators, Thermodynamic analysis of Gas turbine, Operations and performance of Gas Turbine. Combined Cycle Power Plant: Binary vapour cycles, Coupled cycles, Combined Power cycle Plants, Advantages and Limitations, Gas turbine,Steam turbine Power Plant and MHD, Steam Power Plant. Water pollution and Solid waste management in power plants, Effluent quality standards

References

1. Power Plant Engineering, P. K. Nag, McGraw Hill
2. Power Plant Engineering Technology, M.M. Wakil, Mc Graw Hill Publication.
3. Power Plant Engineering, byArrora&Domkundwar‟, Dhanpat Rai & Sons, New Delhi, 2008
4. Power Plant Engineering, by P C Sharma‟, S.K. Kataria& Sons, New Delhi, 2010

Micro Fluidics

MTE24G	**Micro Fluidics**	PEC	3-0-0	3 Credits
Exam Scheme				
Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Course Objectives:

1. To Understand the concept of heat transfer and numerical techniques applied to heat transfer
2. To familiarize the students about the relation of numerical heat transfer and CFD
3. To understand the application of NHT in real life problem

Pre-Requisites: Heat Transfer

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

CO1	Identify Application and changes of micro fluidics in the various engineering aspects
CO2	Apply concept coquette flow, poiseuille flow, time phase flow throw micro channel of different c/s areas in real engineering problems.
CO3	Numerical analysis of capillary flow for a different materials, fluids, cross section and boundary conditions.
CO4	Describe various electromagnetic field effects on flow of micro fluids, simulate forces DEP force on a dielectric sphere
CO5	Design various micro fludic components such as channels, pumps, valves, sensors etc.,

Mapping of COs with POs:

POs→ COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1			1								
CO2	1				1							
CO3	2		2	1		1			1			
CO4		2										
CO5			1									1

Course Contents:

UNIT I

Introduction Origin, Definition, Benefits, Challenges, Commercial activities, Physics of miniaturization, Scaling laws.

UNIT II

Micro-scale fluid mechanics Intermolecular forces, States of matter, Continuum assumption, Governing equations, Constitutive relations. Gas and liquid flows, Boundary conditions, Slip theory, Transition to turbulence, Low Re flows, Entrance effects. Exact solutions, Couette flow, Poiseuille flow, Stokes drag on a sphere, Time-dependent flows, Two-phase flows, Thermal transfer in microchannels. Hydraulic resistance and Circuit analysis, Straight channel of different cross-sections, Channels in series and parallel.

UNIT III

Capillary flows Surface tension and interfacial energy,Young-Laplace equation, Contact angle, Capillary length and capillary rise, Interfacial boundary conditions, Marangoni effect.

UNIT IV

Electrokinetics Electrohydrodynamics fundamentals. Electro-osmosis, Debye layer, Thin EDLlimit, Ideal electroosmotic flow, Ideal EOF with back pressure, Cascade electro-osmotic micropump, EOF of power-law fluids. Electrophoresis of particles, Electrophoretic mobility, Electrophoretic velocity dependence on particle size. Dielectrophoresis, Induced polarization and DEP, Point dipole in a dielectric fluid, DEP force on a dielectric sphere, DEP particle trapping, AC DEP force on a dielectric sphere. Electro-capillary effects, Continuous electro-wetting, Direct electro-wetting, Electro-wetting on dielectric.

UNIT V

Microfluidics components Micropumps, Check-valve pumps, Valve-less pumps, Peristaltic pumps, Rotary pumps, Centrifugal pumps, Ultrasonic pump, EHD pump, MHD pumps. Microvalves, Pneumatic valves, Thermopneumatic valves, Thermomechanical valves,Piezoelectric valves, Electrostatic valves, Electromagnetic valves, Capillary force valves. Microflow sensors, Differential pressure flow sensors, Drag force flow sensors, Lift force flow sensors, Coriolis flow sensors, Thermal flow sensors. Micromixers, Physics of mixing, Pe-Re diagram of micromixers, Parallel lamination, Sequential lamination, Taylor-Aris dispersion. Droplet generators,Kinetics of a droplet, Dynamics of a droplet, In-channel dispensers, T-junction and Cross-junction, Droplet formation, breakup and transport. Microparticle separator, principles of separation and sorting of microparticles, design and applications. Microreactors, Design considerations, Liquid-phase reactors, PCR, Design consideration for PCR reactors.

UNIT VI

Few applications of microfluidics Drug delivery, Diagnostics,Bio-sensing.

References:

1. Nguyen, N. T., Werely,S. T., Fundamentals and applications of Microfluidics, Artech house Inc., 2002. Bruus, H., Theoretical Microfluidics, Oxford University Press Inc., 2008.
2. Madou, M. J., Fundamentals of Microfabrication, CRC press, 2002.
3. Tabeling,P., Introduction to microfluidics, Oxford University Press Inc., 2005.
4. Kirby,B.J., Micro- and Nanoscale Fluid Mechanics: Transport in Microfluidic Devices, Cambridge University Press, 2010. 5. Colin,S., Microfluidics, John Wiley & Sons, 2009

Research Methodology

MOE25A	Research Methodology	Open Elective	3-0-0	3 Credits

Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Semester Exam 60 Marks	Total 100 Marks

Pre-Requisites: None

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

CO1	Understand and Describe importance of research.
CO2	Classify and select appropriate resources for Research.
CO3	Analyze the contents of literature and identify further scope.
CO4	Formulate a Research Problem.
CO5	Develop effective written and oral Presentation skills.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2		3				1		3			2
CO2	2		2	1			1		1			2
CO3	2		3	3			1		1	2		2
CO4	2	3	3	2					2	2		2
CO5	2		1	3			3					3

Course contents:

Unit 1

- Research Concepts – concepts – meaning – objectives – motivation. Types of research – descriptive research – conceptual research – theoretical research – applied research – experimental research.

Unit 2

- Research process – Criteria for good research – Problems encountered by Indian researchers. Formulation of Research Task – Literature Review – Importance & Methods – Sources – Quantification of Cause Effect Relations – Discussions– Field Study – Critical Analysis of Facts Generated

Unit 3

- Hypothetical proposals for future development and testing, selection of Research task.

Unit 4

- Mathematical modelling and simulation – Concepts of modelling – Classification of mathematical models – Modelling with – Ordinary differential equations – Difference equations – Partial differential equations – Graphs – Simulation – Process of formulation of model based on simulation.

Unit 5

- Interpretation and report writing – Techniques of interpretation – Precautions in interpretation – Significance of report writing – Different steps in report writing – Layout of research report – Mechanics of writing research report – Layout and format – Style of writing – Typing – References – Tables – Figures – Conclusion – Appendices.

TEXTS/REFERENCES

1. J.W Bames, Statistical Analysis for Engineers and Scientists, McGraw Hill, N.York
2. Schank Fr., Theories of Engineering Experiments, Tata Mc Graw Hill Publication.
3. C. R. Kothari, Research Methodology, New Age Publishers.
4. Willktnsion K. L, Bhandarkar P. L, Formulation of Hypothesis, Himalaya Publication.

Design of Experiments

MOE25B	Design of Experiments	Open Elective	3-0-0	3 Credits

Mid Sem Test	Continuous Assessment	End-Semester Exam	Total
20 Marks	20 Marks	60 Marks	100 Marks

Pre-Requisites: None
Course Outcomes: At the end of the course the student will be able to:

CO1	Define Taguchi, factorial experiments, variability, orthogonal array, quality loss.
CO2	Plan and design the experimental investigations efficiently and effectively.
CO3	Understand strategy in planning and conducting experiments.
CO4	Evaluate variability in the experimental data using ANOVA.
CO5	Practice statistical software to achieve robust design of experiments.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1		1	1	1	1	1		1	1	1
CO2	3	2	1	3	2	1	2	1	1	2	1	1
CO3	3	2	1	3	2	1	2	1	1	2	1	1
CO4	3	3	1	3	2	1	2	1	1	2	1	1
CO5	2	3	1	2	3	2	2	1	1	2	1	1

Course Contents:

Unit 1
- Introduction: Modern quality control, quality in engineering design, history of quality engineering.
- The Taguchi Approach to quality: Definition of quality, loss function, off-line and on-line quality control, Taguchi`s quality philosophy.

Unit 2
- Full Factorial Designs: Experimentation as learning process, traditional scientific experiments, three factor design, replicating experiments, factor interactions, normal plots of estimated effects, mechanical plating experiments, two factor design, four factor design, Taguchi design and western design.

Unit 3
- Fractional Factorial Design: Fractional factorial design based on eight run experiments, folding over an eight run experimental design, Fractional factorial design in sixteen run, folding over an sixteen run experimental design, blocking two level designs, other two level designs.

Unit 4

- Evaluating Variability: Necessity to analyze variability, measures of variability, the normal distribution, using two level designs to minimize variability, signal-to-noise ratio, minimizing variability and optimizing averages.
- Taguchi Inner and Arrays: Noise factors, experimental designs for control and noise factors, examples.

Unit 5

- Experimental Design for Factors at Three and Four level: Necessity to use more than two level, factors at four levels, factors at three levels.
- Analysis of Variance in Engineering Design: Hypothesis testing concepts, using estimated effects as test statistics, analysis of variance for two level designs, when to use analysis of variance.

Unit 6

- Computer Software for Experimental Design: Role of computer software in experimental design, summery of statistical packages, example of use of software packages.
- Using Experiments to improve Processes: Engineering design and quality improvement, steps to implementing use of engineering design.

TEXTS / REFERENCES:

1. D.C.Montgomery, *Design and Analysis of Experiments*, 5th Edition, John Wiley and Sons, NewYork, 2004.
2. R.H.Lochner and J.E.Matar, *Designing for Quality: An Introduction to the Best of Taguchi and Western Methods of Statistical Experimental Design*, Chapman and Hall, London, 1983.

Advanced Optimization Techniques

MOE25C	Advanced Optimization Techniques	Open Elective	3-0-0	3 Credits

Mid Sem Test	Continuous Assessment	End-Semester Exam	Total
20 Marks	20 Marks	60 Marks	100 Marks

Prerequisite: None
Course Outcomes: At the end of the course the student will be able to:

CO1	Enables to acquire mathematical methods and apply in engineering disciplines.
CO2	Apply methods of optimization to solve a linear, non-linear programming problem by various methods
CO3	Optimize engineering problem of nonlinear-programming with/without constraints, by using this techniques
CO4	Use of dynamic programming problem in controlling in industrial managements.
CO5	Simulate Thermal engineering system problem. Understand integer programming and stochastic programming to evaluate advanced optimization techniques.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1						1		1		1
CO2	2	1	1					1				
CO3		2							1			
CO4	1				2	1				2		1
CO5			1	2	1	1	2		1	2		1

Course Contents:

Unit 1
SINGLE VARIABLE NON-LINEAR UNCONSTRAINED OPTIMITION: One dimensional Optimization methods, Uni-modal function, elimination method, Fibonacci method, golden section method, interpolation methods- quadratic & cubic interpolation methods.

Unit 2
MULTI VARIABLE NON-LINEAR UNCONSTRAINED OPTIMIZATION: Direct search method –Univariant Method – pattern search methods – Powell's – Hook – Jeeves, Rosenbrock search methods – gradient methods, gradient of function, steepest decent method, Fletcher reeves method.
Variable metric method.

Unit 3
GEOMETRIC PROGRAMMING: Polynomials – arithmetic – geometric inequality – unconstrained G.P– constrained G.P

DYNAMIC PROGRAMMING: Multistage decision process, principles of optimality, examples, conversion of final problem to an initial value problem, application of dynamic programming, production inventory. Allocation, scheduling replacement.

Unit 4

LINEAR PROGRAMMING: Formulation – Sensitivity analysis. Change in the constraints, cost coefficients, coefficients of the constraints, addition and deletion of variable, constraints.
Simulation: Introduction – Types – Steps – application – inventory – queuing – thermal system.

Unit 5

INTEGER PROGRAMMING: Introduction – formulation – Gomory cutting plane algorithm – Zero or one algorithm, branch and bound method.
STOCHASTIC PROGRAMMING: Basic concepts of probability theory, random variables Distributions – mean, variance, Correlation, co variance, joint probability distribution stochastic linear, dynamic programming.

TEXTS/REFERENCES:

1. Optimization theory & Applications/ S.S Rao/ New Age International
2. Introductory to operation research/Kasan & Kumar/Springar
3. Optimization Techniques theory and practice / M.C Joshi, K.M Moudgalya/ Narosa Publications.
4. Operation Research/H.A. Taha/TMH
5. Optimization in operations research/R.L Rardin
6. Optimization Techniques/Benugundu & Chandraputla/Person Asia
7. Optimization Techniques /Benugundu & Chandraputla / Pearson Asia

Environmental Engineering and Pollution Control

MOE25D	**Environmental Engineering and Pollution Control**	**Open Elective**	**3-0-0**	**3 Credits**

Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Semester Exam 60 Marks	Total 100 Marks

Course Objectives:

1. To Understand the need of pollution control, its impact, control
2. To familiarize the students about the pollution control techniques
3. To carry out the real life problem

Course Outcomes:

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

CO1	Identify effects of industrialization on environmental pollution in various field.
CO2	Describe photochemical smog, acid Rain, Greenhouse effect, ozone depletion, global warming.
CO3	Suggest pollution control techniques for vehicles, refrigeration, industries, chemical and power plant.
CO4	Do Case study on any industry and analyze carbon exertion rate, water pollution, soil pollution etc.
CO5	Design pollution control devices for vehicle, analyze and find out replacement CFC refrigerant with HC refrigerant.

Mapping of COs with POs:

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2										
CO2	2											1
CO3				1			2	1				1
CO4	2					2			1			
CO5						1						2

Course Content

Unit I

Impact of industrialization and modernization - pollution and pollutants. Air pollution and its effects - air pollution - sources - pollutants – organic and inorganic pollutants - gaseous pollutants– nitrogen oxides - particulate pollutants - effect of pollutants on plants – animals and human beings.

Unit II

photochemical oxidants - photochemical smog – acid Rain - Green house effect - ozone depletion - global warming -Environmental pollution techniques for air pollution - monitoring and Control measures of air pollution - dust control equipment - Electrostatic precipitators and scrubbers.

Unit III

Water pollution and its effects structure - water pollution - sources -Pollutants - industrial effluents - domestic wastes - agrochemicals -Heavy metals - effect of pollutants on plants - animals and human beings Bod - eutrophication - waste water treatment - indicator orgnisms - Oxidation pond - water pollution analysis and monitoring – drinking Water standards. Soil pollution and its effects - soil pollution - sources - solid waste Disposal and their effects - pesticides - types and effect of pollutants on Plants - animals and human beings - biomagnification - fertilizers and its Effect of pollutants on plants - animals and human beings –

UNIT IV

soil pollution Control measures - soil microbes and function - biofertilizer. Noise pollution and its effects - noise pollution - sources – noise Exposure level and standards - impacts - noise control and abatement Measures.

Unit V

Marine pollution - sources and control of marine pollution – criteria Employed for disposal of pollutants in marine system – coastal Management. Radioactive pollution and its impacts - radioactive - sources - effect of Pollutants of plants - animals and human beings - prevention and control Measures of radioactive pollution.

Unit VI

Assessment and control of pollution - environmental standards - Assessment of pollution effects due to air - water - soil and radioactive Pollution - biotechnology in pollution control - microbial role in Pollution control - biomonitoring and bioremediation - pollution control Legislations for air - water - land etc. Biotechnology in pollution control - bioremediation (organic and Inorganic pollutants) - bioleaching and biomineralization.

Text/References

1. Environmental Pollution Analysis:Khopkar.
2. Environmental Science – A study of Inter relationships, E. D. Enger, B. E. Smith, 5th ed., W C B publication.
3. Environmental Pollution Control Engineering: C. S. Rao
4. Bruce Rittman, Perry L. McCarty. Environmental Biotechnology: Principles and Applications, 2nd Edition, McGraw-Hill, 2000.
5. J.N.B. Bell (2002) Air Pollution and Plant Life, 2nd Edition, John Wiley and Sons, New Delhi.

Soft Computing Techniques

MME25E	Soft Computing Techniques	Elective	3-0-0	3 Credits

Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Semester Exam 60 Marks	Total 100 Marks

Pre-Requisites: None
Course Outcomes: At the end of the course, the student will be able to:

CO1	Classify different optimization and evolutionary algorithms.
CO2	Apply optimization techniques to real life problems.
CO3	Learn and apply neural network prediction algorithm to solve engineering problems.
CO4	Understand and apply fuzzy based logic function for predicting results.
CO5	Acquire and use knowledge of genetic algorithm to optimize real life problems.
CO6	Study different hybrid soft computing methods and its applications.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2		2							1		2
CO2	2	2	2	2						1		2
CO3	2	2	2	2						1		
CO4	2	2	2	2						1		
CO5	2	2	2	2						1		
CO6	2	2	2	2						1		1

Unit 1

- **INTRODUCTION**
  Soft Computing: Introduction of soft computing, Evolutionary Algorithms vs. Convectional optimization techniques, various types of soft computing techniques, applications of soft computing.
  Artificial Intelligence: Introduction, Various types of production systems, characteristics of production systems, breadth first search, depth first search techniques, other Search Techniques like hill Climbing, Best first Search, A* algorithm, AO* Algorithms and various types of control strategies. Knowledge representation issues, Prepositional and predicate logic, monotonic and non-monotonic reasoning, forward Reasoning, backward reasoning.

Unit 2

- **OPTIMIZATION CONCEPTS**
  Objective functions, constraints, Search space, local optima, global optima, fitness functions, search techniques, etc.

Unit 3

- **NEURAL NETWORKS**
  Artificial neural network: Introduction, characteristics- learning methods – taxonomy – Evolution of neural networks- basic models – important technologies – applications.
  McCulloch-Pitts neuron – linear separability – hebb network – supervised learning network: perceptron networks – adaptive linear neuron, multiple adaptive linear neuron, BPN, RBF, TDNN- associative memory network: auto-associative memory network, hetero-associative memory network, BAM, hopfield networks, iterative autoassociative memory network & iterative associative memory network – unsupervised learning networks: Kohonenself organizing feature maps, LVQ – CP networks, ART network.

Unit 4

- **FUZZY LOGIC**
  Fuzzy logic: Introduction – crisp sets- fuzzy sets – crisp relations and fuzzy relations: cartesian product of relation – classical relation, fuzzy relations, tolerance and equivalence relations, non-iterative fuzzy sets.
  Membership functions: features, fuzzification, methods of membership value assignments- Defuzzification: lambda cuts – methods – fuzzy arithmetic and fuzzy measures: fuzzy arithmetic – extension principle – fuzzy measures – measures of fuzziness -fuzzy integrals – fuzzy rule base and approximate reasoning : truth values and tables, fuzzy propositions, formation of rules-decomposition of rules, aggregation of fuzzy rules, fuzzy reasoning-fuzzy inference systems-overview of fuzzy expert system-fuzzy decision making.

Unit 5

- **GENETIC ALGORITHM**
  Genetic algorithm- Introduction – biological background – traditional optimization and search techniques – Genetic basic concepts.
  Genetic algorithm and search space – general genetic algorithm – operators – Generational cycle – stopping condition – constraints – classification genetic programming – multilevel optimization – real life problem- advances in GA.

Unit 6

- **HYBRID SOFT COMPUTING TECHNIQUES & APPLICATIONS**
  Neuro-fuzzy hybrid systems – genetic neuro hybrid systems – genetic fuzzy hybrid and fuzzy genetic hybrid systems – simplified fuzzy ARTMAP – Applications: A fusion approach of multispectral images with SAR, optimization of traveling salesman problem using genetic algorithm approach, soft computing based hybrid fuzzy controllers.

TEXTS/REFERENCES:

1. J.S.R.Jang, C.T. Sun and E.Mizutani, “Neuro-Fuzzy and Soft Computing”, PHI /Pearson Education 2004.
2. S.N.Sivanandam and S.N.Deepa, “Principles of Soft Computing”, Wiley India Pvt Ltd, 2011.
3. S.Rajasekaran and G.A.Vijayalakshmi Pai, “Neural Networks, Fuzzy Logic and

Genetic Algorithm: Synthesis & Applications", Prentice-Hall of India Pvt. Ltd., 2006.
4. George J. Klir, Ute St. Clair, Bo Yuan, "Fuzzy Set Theory: Foundations and Applications" Prentice Hall, 1997.
5. David E. Goldberg, "Genetic Algorithm in Search Optimization and Machine Learning" Pearson Education India, 2013.
6. James A. Freeman, David M. Skapura, "Neural Networks Algorithms, Applications, and Programming Techniques, Pearson Education India, 1991.
7. Simon Haykin, "Neural Networks Comprehensive Foundation" Second Edition, Pearson Education, 2005.

Manufacturing Automation

MOE25F	Manufacturing Automation	Open Elective	3-0-0	3 Credits

Mid Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Semester Exam 60 Marks	Total 100 Marks

Pre-Requisites:

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

CO1	
CO2	
CO3	
CO4	
CO5	
CO6	

Mapping of course outcomes with program outcomes

Program Outcomes→ Course Outcomes ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

Course Contents:

UNIT 1
Product cycle, manufacturing functions, types of automation, degree of automation, technical, economic and human factors in automation.

UNIT 2
Technologies- mechanical, electrical, hydraulic, pneumatic, electronic, hybrid systems, comparative evaluation.

UNIT 3
Development of small automation systems using mechanical devices, synthesis of hydraulic circuits.

UNIT 4
Circuit optimization techniques, illustrative examples of the above types of systems.

UNIT 5
Industrial logic control systems logic diagramming, programmable controllers.

UNIT 6
Applications, designing for automation, cost-benefit analysis.

Texts/References:

1. A.N.Gavrilov, *Automation and Mechanization of Production Processes in Instrument Industry*, Pergaman Press, Oxford, 1967.
2. G.Pippengerm, *Industrial Hydraulics*, MGH, New York, 1979.
3. F.Kay , *Pneumatics for Industry*, The Machining Publishing Co., London,1969.
4. Ray, *Robots and Manufacturing Assembly*, Marcel Dekker, New York, 1982.

Modeling and Simulation

MOE25G	Modeling and Simulation	Open Elective	3-0-0	3 Credits

Mid Sem Test	Continuous Assessment	End-Semester Exam	Total
20 Marks	20 Marks	60 Marks	100 Marks

Pre-Requisites: None

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

CO1	Define simulation, its limitations and applications.
CO2	Apply simulation to queuing and inventory situations.
CO3	Acquire knowledge to generate the random numbers for simulation models.
CO4	Analyze the data and verify model of simulation.
CO5	Learn software's and programming languages for developing simulation model.
CO6	Discuss case studies in manufacturing simulation.

Mapping of course outcomes with program outcomes

Program Outcomes→ Course Outcomes ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2											1
CO2	2			1								
CO3	2	2	1	2								1
CO4	2	2	1	2						2	1	
CO5	2	2	2	3						1		2
CO6	2						2			1		

Course Contents:

Unit 1

Introduction to systems and modeling – discrete and continuous system - Limitations of simulation, areas of application - Monte Carlo Simulation.

Unit 2

Discrete event simulation and their applications in queueing and inventory problems.

Unit 3
Random number generation and their techniques - tests for random numbers. Random variable generation.

Unit 4
Analysis of simulation data. - Input modeling – verification and validation of simulation models – output analysis for a single model.

Unit 5
Simulation languages and packages - FORTRAN, C, C++, GPSS, SIMAN V, MODSIM III, ARENA, QUEST, VMAP - Introduction to GPSS – Case studies.

Unit 6
Simulation of manufacturing and material handling system, Caste studies.

Texts/References:

1. Jerry Banks and John S, Carson II "Discrete Event System Simulation", Prentice Hall, 1984.
2. Geoffrey Gordon., "System Simulation", Prentice Hall, 1978.
3. Francis Neelamkovil, "Computer Simulation and Modelling", John Willey and sons,1987.

Seminar

MTE26	Seminar	PCC	0-0-4	2 Credits
Exam Scheme				
Continuous Assessment 25 Marks		Final Evaluation 25 Marks		Total 50 Marks

Course Objectives: Objectives of this course are

1. To understand the open literature
2. To familiarize the students about collection of technical literature, reading and understanding
3. To learn the report writing and presentation

Course Outcomes:

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

CO1	To enable students to aware about recent areas and technologies in thermal engineering and related area.
CO2	To enable students, comprehend importance of system up gradation, improvement and application of new findings for human life.
CO3	To enable students to write technical report and presenting seminar work.
CO4	To enable students to aware about recent areas and technologies in thermal engineering and related area.

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1							1				
CO2		1							1	2		1
CO3		2			1		1	2			1	
CO4								1		1		1

Course Contents/Objectives

The seminar shall consist of the preparation of the report by the candidate on the topic mutually decided by himself and the supervisor. The topic should be a problem in the field of Thermal Engineering and should have the sufficient research orientation. The recent development in the field of the chosen topic needs to be understood by the candidate. The report has to be presented in front of the examiners committee and other faculty members and students of the department. The committee should be set by the PG coordinator and Head, Mechanical Engineering for evaluation of seminar.

Mini Project

MTE27	Mini Project	PCC	0-0-4	2 Credits
Exam Scheme				
Continuous Assessment 25 Marks		End-Sem Evaluation 25 Marks		Total 50 Marks

Course Objectives: Objectives of this course are

1. To apply the basic engineering laws through a modeling/ model/setup
2. To understand the report writing and result analysis
3. To understand the problem formulation

Course Outcomes:

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

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

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1		2	2	1	1	2	2	1	2
CO2	1	1	2	2			2	2	1	2	1	2
CO3	2	2		3					2	2		1
CO4				2				2	2	3		1
CO5		1		2	2			2	2	3		1

Contents/Objectives

To train students in identification, analysis, finding solutions and execution of live thermal engineering problems. It is also aimed to enhance the capabilities of the students.

Individual students are required to choose a topic of their interest. The subject content of the mini project shall be from emerging / thrust areas, topics of current relevance having research aspects or shall be based on industrial visits. Students can also choose live problems from Thermal and Fluids Engineering as their mini project. At the end of the semester, the students should submit a report duly authenticated by the respective guide, to the head of the department.

Mini Project will have internal 50 marks for continuous evaluation and final evaluation for 50 marks.
Internal marks will be awarded by respective guides as per the stipulations given below.
Attendance, regularity of student (20 marks)
Individual evaluation through viva voce / test (30 marks)
Total (50 marks)

Semester end examination will be conducted by a committee consisting of three faculty members. The students are required to bring the report completed in all respects duly authenticated by the respective guide and head of the department, before the committee. Students individually will present their work before the committee. The committee will evaluate the students individually and marks shall be awarded as follows.
Report = 25 marks
Concept/knowledge in the topic = 15 marks
Presentation = 10 marks
Total marks = 50 marks

Semester-III
Project Management

MMECH31	**Project Management**	**PCC**	**0-0-0**	**2 Credits**

Continuous Assessment 50 Marks	PR/OR 50 Marks	Total 100 Marks

Pre-Requisites: None
Course Outcomes: At the end of the course the student will be able to:

CO1	
CO2	
CO3	
CO4	
CO5	
CO6	

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

Course Contents:

Unit-1
- Introduction to Project management**:** Characteristics of projects, Definition and objectives of Project Management, Stages of Project Management, Project Planning Process, Establishing Project organization. Work definition: Defining work content, Time Estimation Method, Project Cost Estimation and budgeting, Project Risk Management, Project scheduling and Planning Tools: Work Breakdown structure, LRC, Gantt charts, CPM/PERT Networks.

Unit-2
- Developing Project Plan (Baseline), Project cash flow analysis, Project scheduling with

resource constraints: Resource Leveling and Resource Allocation. Time Cost Trade off: Crashing Heuristic.

Unit-3

- Project Implementation: Project Monitoring and Control with PERT/Cost, Computers applications in Project Management, Contract Management, Project Procurement Management. Post-Project Analysis.

TEXT BOOKS/REFERENCES:

1. Shtub,BardandGloberson,ProjectManagement:Engineering,Technology,andImplementation,Prentice Hall, India
2. Lock, Gower, Project Management Handbook.

Intellectual Property Rights

MMECH32	Intellectual Property Rights	PCC	0-0-0	2 Credits

Continuous Assessment 50 Marks	PR/OR 50 Marks	Total 100 Marks

Pre-Requisites: None
Course Outcomes: At the end of the course the student will be able to:

CO1	Enumerate and demonstrate fundamental terms such as copy-rights ,Patents ,Trademarks etc.,
CO2	Interpret and follow Laws of copy-rights, Patents, Trademarks and various IP registration Processes to register own project research.
CO3	exhibit the enhance capability to do economic analysis of IP rights, technology and innovation related policy issues and firms' commercial strategies.
CO4	Develop awareness at all levels (research and innovation) of society to develop patentable technologies.
CO5	Apply trade mark law, copy right law, patent law and also carry out intellectual property audits
CO6	Manage and safeguard the intellectual property and protect it against unauthorized use

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1					1		1			
CO2	1		2				1		2			2
CO3						1		1				
CO4						1			1			
CO5			1						1			1
CO6												

Course Contents:

Unit-1
- Introduction to IPR; Overview & Importance; IPR in India and IPR abroad; Patents ;their definition; granting; infringement ;searching & filing; Utility Models an introduction;

Unit-2
- Copyrights ; their definition; granting; infringement ;searching & filing, distinction between related and copy rights; Trademarks ,role in commerce ,importance , protection, registration; domain names;

Unit-3

- Industrial Designs ; Design Patents; scope; protection; filing infringement; difference between Designs & Patents' Geographical indications , international protection; Plant varieties; breeder's rights, protection; biotechnology& research and rights managements; licensing, commercialization; ; legal issues, enforcement ;Case studies in IPR.

TEXT BOOKS/REFERENCES:

1. Prabuddha Ganguli, IPR: Unleashing the Knowledge Economy, published by Tata McGraw Hill 2001.

Project Stage-I

MTE33	Project Stage-I	PCC	0-0-0	10 Credits

Exam Scheme		
Continuous Assessment 50 Marks	End Semester Evaluation 50 Marks	Total 100 Marks

Course Objectives: Objectives of this course are

1. To learn the literature survey
2. To familiarize the students about understanding the open literature, preparation of literature review etc
3. To understand the problem formulation based on the literature review

Course Outcomes:

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

CO1	Identify problems and to plan methodologies to solve problems.
CO2	Carry out exhaustive literature review, study &evaluate collected literature critically and identify the gaps based on the review.
CO3	Select the specific problem for the study as a project
CO4	Demonstrate technical writing while preparing project report and present it to evaluation committeeto demonstrate presentation skills acquired.

Mapping of COs with POs:

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1								1			1
CO2		3								2		1
CO3		2					1	1		2	2	2
CO4	2								1			

Course Contents:

Project (stage-I) should be based on the area in which the candidate has undertaken the dissertation work as per the common instructions for all branches of M. Tech. The examination shall consist of the preparation of report consisting of a detailed problem statement and a literature review. The preliminary results (if available) of the problem may also be discussed in the report. The work has to be presented in front of the examiners panel set by Head and PG coordinator/Faculty Advisor. The candidate has to be in regular contact with his guide and the topic of dissertation must be mutually decided by the guide and student.

Semester IV

Project Stage-II

MTE41	**Project Stage-II**	PCC	0-0-0	20 Credits
Exam Scheme				
Continuous Assessment 100 Marks		PR/OR 100Marks		Total 200 Marks

Course Objectives: Objectives of this course are

1. To develop the setup/model based on the literature survey
2. To familiarize the students about the carrying out experimentation/ computer programming/ software
3. To understand the report writing, analysis of result, preparation of manuscript etc.

Course Outcomes:

At the end of the course, student should be able to:

CO1	Solve identified technical problem using acquired knowledge and skill.
CO2	Use latest equipment, instruments, software tools, infrastructure and learning resources available to solve the identified project problem.Procure resources, if required.
CO3	Interpret theoretical/experimental findings using available tools
CO4	Compare the results obtained with results of similar studies
CO5	Draw conclusions based on the results.

Mapping of COs with POs:

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1								1			1
CO2		3								2		1
CO3		2					1	1		2	2	2
CO4	2								1			
CO5		1						1				2

Course Contents/Objective

The Project Work will start in semester III and should preferably be a problem with research potential and should involve scientific research, design, generation/collection and analysis of data, determining solution and must preferably bring out the individual contribution. The dissertation should be presented in standard format as provided by the department/guide. The candidate has to prepare a detailed project report consisting of introduction of the problem,

problem statement, literature review, objectives of the work, methodology (experimental set up or numerical details as the case may be) of solution and results and discussion. The report must bring out the conclusions of the work and future scope for the study. The work has to be presented before the panel of examiners consisting of an approved external examiner, internal examiner/guide as decided by the Head and PG coordinator/Faculty Advisor. The candidate has to be in regular contact with his guide throughout the project duration.