Pimpri Chinchwad Education Trust's

PIMPRI CHINCHWAD COLLEGE OF ENGINEERING

SECTOR NO. 26, PRADHIKARAN, NIGDI, PUNE 411044

An Autonomous Institute Approved by AICTE and Affiliated to SPPU, Pune

DEPARTMENT OF MECHANICAL ENGINEERING

Curriculum Structure of
M. Tech. Mechanical Heat Power Engineering

and

Syllabus of F. Y M. Tech. Courses

(Approved by BoS Mechanical Engineering)

(Course 2020)

Effective from Academic Year 2020-21

Institute Vision

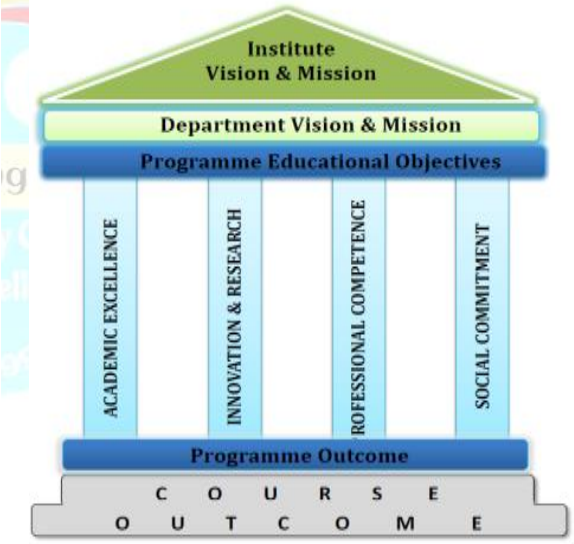
To Serve the Society, Industry and all the Stakeholders through the **Value-Added Quality Education.**

Institute Mission

To serve the needs of society at large by establishing State-of-the-Art Engineering, Management and Research Institute and impart attitude, knowledge and skills with quality education to develop individuals and teams with ability to think and analyze right values and self-reliance.

Quality Policy

We at PCCOE are committed to impart Value Added Quality Education to satisfy the applicable requirements, needs and expectations of the Students and Stakeholders. We shall strive for academic excellence, professional competence and social commitment in fine blend with innovation and research. We shall achieve this by establishing and strengthening state-of- the-art Engineering and Management Institute through continual improvement in effective implementation of Quality Management System.



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INDEX

Sr. No.		Content	Pg. No
1.		Abbreviations	1
2.		Curriculum Structure	2
	a	List of Electives	4
	b	List of Audit Courses	4
	c	List of Open Electives	5
3.		Curriculum Syllabus (Semester-I)	9
4.		Curriculum Syllabus (Semester-II)	29
5.		Curriculum Syllabus (Semester-III)	49
6.		Curriculum Syllabus (Semester-1V)	54
7.		Annexure-I Syllabus of Open Electives	57
8.		Annexure-II Syllabus of Audit Courses	98

ABBREVIATIONS

Abbreviations	Course Full Name
PCC	**P**rofessional **C**ore **C**ourse
PEC	**P**rofessional **E**lective **C**ourse
OEC#	**O**pen **E**lective **C**ourse
PROJ	**Proj**ect, Mini / Minor **Proj**ects, Integrated **Proj**ects
SEM	**Sem**inar
INTR	**Inter**nship
LS	**L**ife **S**kill
AUDIT*	**A**udit **C**ourse
MO	**Massive Open Online Courses**

Note : * Indicates that these courses are at Institute level

The Course offered by the other department

CURRICULUM STRUCTURE

STRUCTURE FOR IST YEAR M. TECH (HEAT POWER ENGINEERING)

SEMESTER I & II

M.Tech Structure		Sem-I	Teaching Scheme				Examination Scheme					
Course Code	**Course Type**	**Course Name**	**L**	**P**	**H**	**CR**	**IE1**	**IE2**	**ETE**	**TW**	**OR**	**Total**
MMH1401	PCC	Research Methodology & IPR	3	-	3	3	20	30	50	-	-	100
MMH1402	PCC	Advanced Thermodynamics & Combustion.	3	-	3	3	20	30	50	-	-	100
MMH1403	PCC	Advanced Fluid Dynamics	3	-	3	3	20	30	50	-	-	100
MMH1404	PCC	Professional Core Lab-I (ATC & AFM)	-	2	2	1	-	-	-	50	50	100
MMH1501	PEC	Professional Elective-I	3	-	3	3	20	30	50	-	-	100
MMH1502	PEC	Professional Elective-II	3	-	3	3	20	30	50	-	-	100
MMH1503	PEC	Professional Elective Lab-I (Elec. I & II)	-	2	2	1	-	-	-	50	50	100
*	OEC	Open Elective-I	2	-	2	2	20	-	30	-	-	50
MMH1911	PCC	Skill Development Lab – I (Software Skill)	-	2	2	1	-	-	-	50	-	50
MMH1961	Audit	Audit Course – I	**1**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
		Total	**18**	**6**	**24**	**20**	**120**	**150**	**280**	**150**	**100**	**800**

M.Tech Structure		Sem-II	Teaching Scheme				Examination Scheme					
Course Code	**Course Type**	**Course Name**	**L**	**P**	**H**	**CR**	**IE1**	**IE2**	**ETE**	**TW**	**OR**	**Total**
MMH2405	PCC	Advanced Heat Transfer	3	-	3	3	20	30	50	-	-	100
MMH2406	PCC	Computational Fluid Dynamics	3	-	3	3	20	30	50	-	-	100
MMH2407	PCC	Professional Core Lab-II (AHT & CFD)	-	2	2	1	-	-	-	50	50	100
MMH2504	PEC	Professional Elective-III	3	-	3	3	20	30	50	-	-	100
MMH2505	PEC	Professional Elective-IV	3	-	3	3	20	30	50	-	-	100
MMH2506	PEC	Professional Elective Lab-II	-	2	2	1	-	-	-	50	50	100
**	OEC	Open Elective –II	2	-	2	2	20	-	30	-	-	50
MMH1912	LS	Skill Development Lab – II (Written & Oral Communication)	-	2	2	1	-	-	-	50	-	50
MMH2701	PROJ	Integrated Mini-Project	-	6	6	3	-	50	-		50	100
MMH2962	Audit	Audit Course –II	1	-	1	-	-	-	-	-	-	-
		Total	**15**	**12**	**27**	**20**	**100**	**170**	**230**	**150**	**150**	**800**

Abbreviation: **L**- Lecture; **P**- Practical; **H**- Hours; **CR**- Credits; **IE 1** – Internal Evaluation-1; **IE 2** – Internal Evaluation-II; **ETE** – End Term Examination; **TW** – Term Work; **OR** – Oral Exam

** Open Elective code will be as per course chosen

STRUCTURE FOR IIND YEAR M. TECH (HEAT POWER ENGINEERING)
SEMESTER-III

M Tech Structure		Sem – III	TEACHING SCHEME				EXAMINATION SCHEME					
Abbr	**Course Type**	**Courses**	**L**	**P**	**H**	**CR**	**IE1**	**IE2**	**ETE**	**TW**	**OR**	**TOTAL**
MMH3702	PROJ	Dissertation Phase - I [Company/ In-house project]	-	20	20	10	-	100	-	-	100	200
MMH3703	SEM	Seminar	-	04	04	02	-	-	-	50	50	100
MMH3801	INTR	Internship [Company/ In-house project] /	-	04	04	02	-	50	-	-	50	100
OR												
MMH3981	MO	MOOC's / Entrepreneurship	-	04	04	02	-	50	-	-	50	100
		Total	**-**	**28**	**28**	**14**	**-**	**150**	**-**	**50**	**200**	**400**

SEMESTER-IV

M Tech Structure		Sem – IV	TEACHING SCHEME				EXAMINATION SCHEME					
Abbr	**Course Type**	**Courses**	**L**	**P**	**H**	**CR**	**IE1**	**IE2**	**ETE**	**TW**	**OR**	**TOTAL**
MMH4704	PROJ	Dissertation Phase - II [Company/ In-house project]	-	24	24	12	-	200	-	-	200	400
MMH4982	MO	MOOC's	-	4	4	2	-	50	-	-	50	100
		Total	**-**	**28**	**28**	**14**	**-**	**250**	**-**	**-**	**250**	**500**

Abbreviation: L- Lecture; **P**- Practical; **H**- Hours; **CR**- Credits; **IE 1** – Internal Evaluation-1; **IE 2**– Internal Evaluation-II; **ETE** – End Term Examination; **TW** – Term Work; **OR** – Oral Exam

LIST OF ELECTIVES

	Elective-I		Elective-II
MMH1501A	Refrigeration & Cryogenics	**MMH1502A**	Air Conditioning System Design
MMH1501B	Energy Conservation and Management	**MMH1502B**	Design of Solar and Wind Systems
MMH1501C	Mathematical Methods in Heat Power Engineering	**MMH1502C**	Gas Dynamics

	Elective-III		Elective-IV
MMH2504A	Building Energy System & Technology	**MMH2505A**	Design of Thermal Systems
MMH2504B	Thermal and Electrical Energy Storage	**MMH2505C**	Turbulent Flow
MMH2504C	Combustion in Gas Turbines & IC Engines	**MMH2505D**	Two phase flow

LIST OF AUDIT COURSES

	SEM-I		SEM-II
M_1961A	Constitution of India	**M_2962A**	Team Building & Leadership
M_1961B	Value Education	**M_2962B**	English for Research writing
M_1961C	Stress Management	**M_2962C**	Disaster Management

LIST OF OPEN ELECTIVES

OFFERED BY HEAT POWER ENGINEERING

	Open Elective – I		Open Elective –II
MMH1601A	Electronic Cooling	**MMH2602A**	Waste Management for Smart Cities
MMH1601B	Green Buildings	**MMH2602B**	Battery Management for Electric Vehicles
MMH1601C	System Modeling and Simulation	**MMH2602C**	Renewable Energy Sources

OFFERED BY DESIGN ENGINEERING

	Open Elective – I		Open Elective –II
MMD1601A	Advanced Materials	**MMD2602A**	Room Acoustics
MMD1601B	Optimization Methods	**MMD2602B**	Design Thinking
MMD1601C	Modeling & Simulation of Dynamic Systems	**MMD2602C**	Reliability Engineering

OFFERED BY VLSI & EMBEDDED SYSTEMS

	Open Elective – I		Open Elective –II
MET1601A	Automotive Electronics & Applications	**MET2602A**	Drone Programming for Beginners
MET1601B	Industrial Drives	**MET2602B**	Instrumentation and Measurement
MET1601C	Basics of FPGA and CPLD	**MET2602C**	Microcontrollers and Microprocessors applications
MET1601D	Robotics	**MET2602D**	Electronics Implementation Platforms

OFFERED BY COMPUTER ENGINEERING

	Open Elective – I		Open Elective –II
MCE1601A	Programming with Python	**MCE2602A**	Image Processing with MATLAB
MCE1601B	Software Engineering Basics	**MCE2602B**	Linux Essentials
MCE1601C	Basics of Machine learning	**MCE2602C**	Design with UMI

OFFERED BY CIVIL- CONSTRCTION MANAGEMENT

	Open Elective – I		Open Elective –II
MCI1601A	Project Management and Finance	**MCI2602A**	Contracts, Tendering and Arbitration
MCI1601B	Green Technology	**MCI2602B**	Total Quality Management
		MCI2602C	Operation Research

OFFERED BY INFORMATION TECHNOLOGY

	Open Elective – I		**Open Elective -II**
MIT1601A	Business Analytics	**MIT2602A**	Cryptography and
MIT1601B	R Programming	**MIT2602B**	Cloud Computing and Security
MIT1601C	Cost Management of Engineering Project	**MIT2602C**	Bitcoin : Fundamentals of Crypto Currencies

Course Syllabus
Semester-I

Program:	**M. Tech. Mechanical (Heat Power Engineering)**				**Semester: I**	
Course:	**Research Methodology and IPR**				**Code: MMH1401**	
Teaching Scheme			**Evaluation Scheme**			
Lecture	**Hours**	**Credit**	**IE 1**	**IE 2**	**ETE**	**Total**
3	**3**	**3**	**20**	**30**	**50**	**100**

Pre-requisite: Project and seminars in undergraduate

Objectives:

1. To select and define appropriate research problem and parameters with appropriate methodology.
2. To understand statistical techniques for the specific perspective data in an appropriate manner.
3. To make predictions and decisions for the data set using open-source software.
4. To understand the mathematical modeling and its predicting capability.
5. To learn the various steps in research writing and publication process
6. To introduce fundamental aspects of Intellectual property rights

Outcomes:

After learning the course, the students should be able to:

1. Define a research problem and use appropriate research methodology
2. Examine data using different hypothesis tests and make conclusions about acceptance or rejection of sample data.
3. Analyze numerical data, using standard procedures of probability theory to predict the performance.
4. Develop a mathematical model and analyze the prediction capabilities
5. Write a research paper and research proposal.
6. Write a concept note and prepare to file an IP.

Detailed Syllabus:

Unit	**Description**	**Duration, h**
1.	**Research Problem and Research Design** Objectives, Motivation, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Criteria of Good Research Definition and Feasibility study of research problem, Sources of research problem, Meaning of Hypothesis, Characteristics of Hypothesis, Errors in selecting a research problem, Concept & need of research design	**6**
2.	**Applied Statistics** Measures of Variability: Standard Deviation, variance, Quartiles, Interquartile Range Inferential Statistics: Statistical Significance (p values), Pearson's r test, t- test, Chi square test, ANOVA (Analysis of variance)	**6**
3.	**Probability** Sampling, Types of Sampling, Probability Distribution: Binomial Distribution, Poisson Distribution, Normal Distribution, Case Study: Develop a model for Prediction and Decision Making for the data set using open-source software	**6**
4.	**Mathematical Modeling and prediction of performance** Types of Modeling, Types of solutions to mathematical models, Steps in Setting up a computer model to predict performance of experimental system, Validation of results, Multi-scale modeling and verifying performance of process system, Nonlinear analysis of system and asymptotic analysis, Sensitivity analysis.	**6**

5.	**Research Report writing and Publication** Research Report: Dissemination of research findings, outline and structure of research report, different steps and precautions while writing research report, methods and significance of referencing. Publishing Research work: Selection of suitable journal for publishing research work, Open access Vs Subscription Journals, Identifying indexing of selected journals, Impact factor of the journal, structure of research paper, Check for plagiarism of the article, Research paper submission and review process.	**6**
6	**Intellectual property Rights** Definition of IPR, Classification of IP, Patentable and non-patentable inventions, statutory exceptions, Persons entitled to apply for patents. Prior Art Search, Patentability Criteria, Patent Filing Procedure, Forms and Fees, Case Study of Patent, Copyright.	**6**
	Total	**36**

Textbooks:

1. C. R. Kothari, Research Methodology: Methods and Techniques, New Age International, 2nd Edition, 1985
2. Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, 2nd Edition.,2010.
3. Ramakrishna B and Anil Kumar H S., Fundamentals of IPR, Notion Press, 2016
4. Virendra Kumar Ahuja, IPR in India, LexisNexis Butterworths Wadhwa Nagpur, 2017

Reference Books:

1. Stuart Melville and Wayne Goddard, Research methodology: An Introduction for Science & Engineering students
2. S.D. Sharma, Operational Research, Kadar Nath Ram Nath & Co.
3. Wayne Goddard and Stuart Melville, Research Methodology: An Introduction, Juta and Company Ltd, 2004

IE Activities:

1. Write a review paper based on detailed literature survey and cheque for plagiarism.
2. Write a research proposal on your domain specific research problem.
3. Write a concept note and prepare to file an IP.

Program:	M. Tech. Mechanical (Heat Power Engineering)		Semester: I			
Course:	Advanced Thermodynamics and Combustion		Code: MMH1402			
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
3	3	3	20	30	50	100

Pre-requisite: Mathematics, Engineering Thermodynamics

Objectives:

1. To understand the entropy and exergy balance of thermodynamic systems
2. To get familiar with the use of property tables and charts of pure substances
3. To acquaint with various thermodynamic property relations and their applications
4. To get familiar with composition of gas mixtures
5. To get familiar with combustion reaction of fuels
6. To understand the criteria of chemical equilibrium for gas mixtures

Outcomes:

After learning the course, the learners will be able to

1. Apply entropy and exergy balance to thermodynamic systems.
2. Utilize property tables and charts of pure substances
3. Determine various non-measurable properties by using thermodynamic property relations
4. Evaluate the composition of gas mixtures
5. Design an elemgreentary combustion system
6. Evaluate the equilibrium constant for gas mixture

Detailed Syllabus

Unit	Description	Duration h
1.	**Second Laws of Thermodynamics, Entropy and Exergy:** Carnot Theorem, Clausius inequality, Entropy and Entropy relation, Increase of entropy principle, Entropy change of incompressible and simple compressible system, Entropy transfer with heat and mass, Entropy balance of closed system and control volume Exergy: concept of availability/exergy, Exergy of energy and transfers. Reversible work and Irreversibility, Exergy change of closed system and control volume, Decrease of Exergy principle, Exergy balance of closed system and control volume, Exergy destroyed, Second law efficiency of steady flow devices	8
2.	**Properties of Pure Substances:** Phase change process of pure substances, P-v-T surface, Use of property tables and charts. Gibb's phase rule Ideal gas equation of state, Deviation from ideal gas behavior, compressibility factor, Law of corresponding states, generalized compressibility chart, other equations of state	6
3.	**Thermodynamic Property Relations:** Partial Differentials and related rules, Helmholtz and Gibbs functions, The Maxwell relations, general relations for du, dh, ds, and Cv and Cp, Clapeyron equation, Clausius- Clapeyron equation, Joule Thomson Coefficient, Δh, Δu, Δs of real gases.	6

4.	**Gas mixture:** Composition of a gas mixture, Mass fraction, Mole fraction, PVT behavior of a gas mixture: Ideal and real gases, properties of a gas mixture: Ideal and real gases.	**6**
5.	**Thermodynamics of Combustion reaction:** Theoretical and actual combustion processes, Enthalpy of formation and enthalpy of combustion, First law analysis of reacting systems, adiabatic flame temperature	**5**
6.	**Chemical equilibrium:** Criterion for chemical equilibrium, the equilibrium constant for ideal gas mixtures, chemical equilibrium for simultaneous reaction, variation of equilibrium constant with temperature.	**5**
	Total	**36**

Text Books:

1. Y. Cengel, M.A. Boles, and M. Kanoglu: Thermodynamics – An Engineering Approach, McGraw Hill, 9th edition, 2019.
2. P. K. Nag, Engineering Thermodynamics, McGraw Hill, 6th Edition, 2017.
3. R. Balmer, Modern Engineering Thermodynamics, Academic Press, Elsevier, 2011.
4. D. Winterbone and A. Turan, Advanced Thermodynamics for Engineers, Butterworth-Heinemann, Elseveir, 2nd edition, 2015.

Reference Books:

1. K. Wark, Advanced Thermodynamics for Engineers, McGraw Hill, 1994.
2. M. Moran, H. Shapiro, D. Boettner, and M. Bailey, Fundamentals of Engineering Thermodynamics, Wiley, 9th edition, 2018.
3. C. Borgnakke, and R. Sonntag, Fundamentals of Thermodynamics, Wiley, 10th edition, 2019.
4. M. Achuthan, Engineering Thermodynamics, PHI Learning Pvt. Ltd, 2nd edition, 2009.

Program:	M. Tech. Mechanical (Heat Power Engineering)		Semester: I			
Course:	Advanced Fluid Dynamics		Code: MMH1403			
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
3	3	3	20	30	50	100

Pre-requisite: A fundamental course in Fluid Mechanics, Integral Calculus, Partial Differential Equations

Objectives:

1. To impart basic understanding of various governing equations of fluid flow.
2. To enable the learner to apply the governing equations to different practical flow conditions.
3. To be able to differentiate between characteristics of viscous and in-viscid flow, laminar and turbulent flow

Outcomes:

After learning the course, the students should be able to:

1. Apply the governing equations of fluid flow
2. Apply Navier Stokes Equation so as to obtain the solutions for different fluid flow problems
3. To utilize potential theory to derive exact and approximate solution of elementary fluid flows
4. Develop boundary layer formations and locate the separation of flow from the body
5. Analyze the role of turbulence and turbulence modeling in engineering applications.
6. Apply the techniques of particle image velocimetry and hot-wire anemometry to investigate complex fluid flow

Detailed Syllabus:

Unit	Description	Duration, h
1.	**Governing Equations** Fluid as continuum and Knudsen number, Langragian and Eulerian description, Substantial or Total derivatives, Translation, Rate of deformation, Vorticity. Differential and Integral form of conservation equations- mass, momentum and energy, Reynolds Transport Theorem	5
2	**Exact Solution of Navier Stokes Equation** Derivation of Navier-Stokes Equation, Exact solutions of Navier-Stokes Equation, parallel flow in a straight channel, Couette flow, Hagen Poiseuille flow.	6
3	**Potential Theory** A Control Volume approach for the derivation of Euler's Equation, Euler's equation along a streamline, Bernoulli's Equation, Uniform flow, Source or sinks flow, Vortex flow, Kelvin's theorem, Application of complex number theory for solution of potential flow problems	7
4	**Laminar Boundary layer theory** Boundary layer assumptions, equations, Flow over a flat plate, Similarity (Blasius) solution, Momentum integral method, Flow separation, Effect of pressure gradient	6
5.	**Turbulent flow** Characteristics of turbulence, laminar-turbulent transition, Correlation functions, Mean and fluctuations, Governing equations, Turbulent boundary layer, Boundary conditions, shear stress models, Prandtl's mixing length, Velocity profile over a flat plate and in pipes, Solution methods for turbulent flow-DNS, RANS,LES	7

6	**Experimental Fluid Dynamics** Flow measurement devices, flow visualization techniques, hot wire anemometry, particle image velocimetry, sources of error in measurement, uncertainty analysis	**5**
	Total	**36**

Text Books:

1. F. W. Robert, McDonald T. Alan, Introduction to Fluid Mechanics, Fourth Edition, John Wiley & Sons, 1995.
2. F. M. White, Viscous Fluid Flow, Third Edition, McGraw-Hill Series of Mechanical Engineering, 2006.
3. K.Muralidhar and G Biswas., Advanced Engineering Fluid Mechanics, Second Edition, Narosa, 2005.

Reference Books:

1. P. K. Kundu, I. M. Kohen and David R. Dawling, Fluid Mechanics, Fifth Edition, 2005 I. Shames, Mechanics of Fluids, McGraw Hill, 2003.
2. J. D. Anderson Jr., Fundamentals of Aerodynamics, McGrawHill, 2005.
3. H Schlichting., Boundary Layer Theory, Springer Verlag, 2000.
4. H. Tennekes and J.L. Lumley, A First Course in Turbulence, The MIT press, 1972.

PROFESSIONAL CORE LAB - I						
Program:	**M. Tech. Mechanical (Heat Power Engineering)**			**Semester: I**		
Course:	**Professional Core Lab-1 (ATC & AFD)**			**Code: MMH1404**		
Teaching Scheme			**Evaluation Scheme**			
Practical	**Hours**	**Credit**	**TW**	**PR**	**OR**	**Total**
2	**2**	**1**	**50**	**--**	**50**	**50**

Objectives:

This course intends to provide students the tools required to simulate, correlate and validate theoretical concepts and understand the basic principles.

Outcomes:

After learning the course, the students should be able to:

1. Estimate thermodynamic properties, composition of gas mixtures and adiabatic flame temperature during combustion reaction
2. Calculate lift and drag forces on bodies
3. Estimate friction factor and pressure losses in pipe flow
4. Apply measurement instrumentation in fluid flow problems

Guidelines:

1. Total experiments to be conducted are Three from Part A and Three from Part B
2. Total: 6 experiments 12 hours

Detailed Syllabus:

Part A: Advanced Thermodynamics & Combustion (ANY Three)

Expt.	Description	Duration, h
1.	Use of computer software (EES) to solve problems related to Properties of Pure Substances	6
2.	Generation of phase change diagram of pure substance by using EES software.	
3.	Study of the effect of percentage of theoretical air on adiabatic flame temperature and equilibrium composition for a hydrocarbon fuel by using computer software (EES)	
4.	Determination of composition of gas mixtures using EES software	
	Total (Any three)	**06**

Part B: Advanced Fluid Dynamics (ANY Three)

Expt.	Description	Duration, h
1.	Flow over a cylinder/sphere at different Re. Pressure variation over the body and drag estimation	6
2.	Flow past an aerofoil: Pressure measurements, calculation of lift	
3.	Friction factor and skin friction coefficient determination: incompressible flow through pipes/ducts of variable cross section	
4.	Laminar/Turbulent boundary layer over a flat plate.	
5.	Velocity measurement using hot wire anemometer	
6.	Demonstration of Particle Image Velocimetry (PIV) technique	
	Total (Any three)	**06**

Program:	M. Tech. Mechanical (Heat Power Engineering)		Semester: I			
Course:	Refrigeration and Cryogenics (Elective)		Code: MMH1501A			
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
3	3	3	20	30	50	100

Pre-requisite: Refrigeration and Air Conditioning

Objectives:

1. To apply knowledge of refrigeration and cryogenics for different applications
2. To design and develop the refrigeration and cryogenics system for various Industrial, medical, space and other application.

Outcomes:

After learning the course, the students should be able to:

1. Select refrigeration system and refrigerants for various applications
2. Analyze and evaluate multi-pressure systems.
3. Evaluate COP for Single and two stage Cascade systems.
4. Design of compressors, condensers and evaporators in refrigeration systems.
5. Evaluate performance of cryogenic refrigeration systems.

Detailed Syllabus:

Unit	Description	Duration, h
1.	**Applications of Refrigeration Systems:** Refrigeration applications: Vapour compression refrigeration, application in food preservation-cold storage, transport, air-conditioning, steam jet refrigeration, Adsorption refrigeration.	4
2	**Multi-pressure Systems** Multistage compression with intercooling, types of multi-evaporator and compression systems, multiple evaporators at same temperatures with single compressor and expansion valve, multiple evaporators at different temperatures with single compressor, multiple expansion valves and back pressure valves.	7
3.	**Cascade Refrigeration system** Introduction to cascade refrigeration system, derivation of COP of a cascade system, cop of two stage cascade system, pressure –temperature and p-h diagram for production of carbon dioxide or dry ice.	6
4.	**Equipment used in Refrigeration systems and Refrigerants:** Classification of compressors, performance, selection as per the requirement. Capacity control of reciprocating and centrifugal compressors. Design and selection of evaporators, condensers, system balance, and safety control systems, motor selection.	6
5.	**Refrigerants and Vapor Absorption Systems:** Natural refrigerants and alternative refrigerants, Vapor absorption refrigeration and its performance evaluation, single effect and double effect systems, Electrolux Refrigerator.	6
6.	**Cryogenics and its applications**: Properties of Cryogenic Fluids, Gas-Liquefaction and Refrigeration Systems, Ideal Liquefaction System, Linde-Hampson System, Claude Cycle, Joule Thomson System, Cop, Fom, And Gas Separation: Ideal Cycle and Work Requirement.	7
	Total	36

Text Books:

1. R.J. Dossat, “Principles of Refrigeration”, Pearson Education Asia, 2013.
2. C.P. Arora, “Refrigeration and Air conditioning”, Tata McGrawHill, 2006.
3. W.F. Stoecker and J.W. Jones, “Refrigeration and Air conditioning”, McGraw Hill Book Company, New York, 1982
4. R. Barron, “Cryogenic systems”, McGraw Hill Company, New York, 1966.
5. R.S. Khurmi and J.K. Gupta. A Text Book Of Refrigeration and Air Conditioning, S. Chand Publications, 2008.

Reference Books:

1. P.C. Koelet, “Industrial Refrigeration: Principles, Design and Applications”, Macmillan, 2017.
2. K. D. Timmerhaus and T.M. Flynn “Cryogenic process engineering” Springer Science, 2013

Program:	M. Tech. Mechanical (Heat Power Engineering)		Semester: I			
Course:	Energy Conservation & Management (Elective)		Code : MMH1501 B			
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
3	3	3	20	30	50	100

Pre-requisite:

1. Thermodynamics, 2. Fluid Mechanics 3. Heat Transfer 4. Elements of Electrical Engineering

Objectives: Following concepts to be taught to the students,

1. Importance of Energy Conservation, Efficiency & Management.
2. How to conduct energy audits and analyze / benchmark performance
3. Methods to reduce consumption of energy and optimize energy cost.
4. How to improve energy efficiency of overall system.
5. Significance of Waste heat (Energy) recovery
6. Role of controls in enhancing energy efficiency

Course Outcomes:

1. Understand different levels of energy audit for buildings, understand difference between audits and commissioning of building systems
2. Assess energy data and perform benchmarking with respect to a standard or historical baseline, and thereby evaluate and prioritize energy conservation measures based on cost savings and capital investment.
3. Evaluate and suggest various methods to reduce energy consumption / save energy in various industrial equipment and systems, understand reporting procedures for energy audits

Detailed Syllabus:

Unit	Description	Duration, h
1	**Energy Scenario** Overview of energy sources, Indian energy scenario, Sectoral energy consumption, Energy needs of growing economy, Energy security, Energy conservation and its importance, Energy and environment linkage, climate change, UNFCCC, Paris agreement, energy efficiency and sustainability, e-mobility	3
2.	**Energy Audits and Commissioning** Need, Energy Audit-Types, Scope, Methodology, Instruments used & software's, Monitoring & Verification, Analysis and recommendations of energy audit – examples (including Report preparation); ASHRAE Level 1, 2 & 3 audits for buildings, commissioning of building systems, requirements of BEE / LEED / IGBC for audits / commissioning, review of case studies	6
3	**Energy Conservation in Boilers and Steam Utilities** Types, Analysis of Losses, Performance Evaluation, Feed Water Treatment, Blow Down, Energy Conservation Opportunities, Case Studies. Assessment of steam distribution losses and Improvement, Steam Leakages, Steam Trapping, Condensate and Flash Steam Recovery System	6
4	**Compressed Air Systems, Fans and Pumps** Types of air compressors, compressor efficiency, efficient compressor operation, compressed air systems components, capacity assessment, and leakage test Fans & Blowers: Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities Pumps and Pumping System: Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities.	7
5.	**Electrical Energy Management and Lighting Optimization** Electricity billing, Electrical load management and maximum demand control, Power factor, improvement and its benefit, Selection and location of capacitors;	7

	Distribution and transformer losses; Electrical motors- types, efficiency and selection, Speed control, Energy efficient motors; Lighting - Lamp types and their features, recommended illumination levels, lighting system, Advances in Electrical Fittings (Soft Starter / Electronic Ballast,etc.);	
6.	**Energy Economics & WHR -** Costing of Utilities- Determination of cost of steam, natural gas, compressed air and electricity**.** Basics of Waste Heat Recovery, First and Second Law Efficiencies, Financial Analysis Techniques - Simple payback, Time value of money, Net Present Value (NPV), Return on Investment (ROI), Internal Rate of Return (IRR), Risk and Sensitivity analysis for Energy Projects, Risk & Sensitivity Analysis, ESCO;	**7**
	Total	**36**

Text Books –

1. G. L. Witte, Phillips S.Scbmidt and Daid R. Brown, Industrial Energy Management and Utilization, Hemisphere Publishing Corporation, Washington, 1998.
2. C. B. Smith, K.E. Parmenter, Energy Management Principles, Applications, Benefit and Saving, Pergamon Press, New York, 2015.
3. Energy Performance assessment for equipment and Utility Systems. -Vol. 2,3.4 BEE Govt. of India
4. A. L Kohan, Boiler Operator ‘s Guide Fourth Edition, McGraw Hill,1998.
5. O.P. Gupta, Element of Fuel Furnaces and Refractories, Edition-Second, Khanna Publishers, 1997
6. C.B. Smith, Efficient Electrical Use, Pergamon Press, New York, 1978
7. M. Krarti, Energy Audit of Building Systems - An engineering approach, CRC Press, 2016

Reference Books

1. Albert Thumann, William J. Younger, CEM, Handbook of Energy Audit, The Fairmont Press Inc., 7th Edition.
2. W. C. Turner, Energy Management Handbook, The Fairmont Press Inc., 5th Edition, Georgia.
3. Y. A. Abbi, S. Jain, Handbook on Energy Audit and Environment management, TERI, Press,New Delhi, 2006
4. Energy Information Handbook – Berkeley Lab

Program:	**M. Tech. Mechanical (Heat Power Engineering)**		**Semester: I**			
Course:	**Mathematical Methods in Heat Power Engineering (Elective)**		**Code: MMH1501C**			
Teaching Scheme			**Evaluation Scheme**			
Lecture	**Hours**	**Credit**	**IE 1**	**IE 2**	**ETE**	**Total**
3	**3**	**3**	**20**	**30**	**50**	**100**

Pre-requisite: Basic knowledge of advanced calculus including methods for solving ODEs and basics of PDEs. Matrices. Laplace and Fourier Transform

Objectives:

1. To familiarize students with numerical techniques to solve ODE and PDEs including boundary value problems
2. To introduce them to the important mathematical tool of Calculus of Variations, Finite element Method and Pseudo analytical techniques.

Outcomes:

After learning the course, the students should be able to:

1. Apply the numerical method techniques for solving ordinary differential equation.
2. Apply the numerical method techniques for solving partial differential equation to analyze the solution of different type's heat equations.
3. Apply calculus of variation techniques for finding maxima and minima of functional.
4. Apply Finite element method to solve initial and boundary value problems for one dimension.
5. Apply numerical methods to find the Eigen values and Eigen vectors and analyze the nature of Eigen value.
6. Apply Pseudo analytical techniques to analyze the solution of Partial differential equation

Detailed Syllabus:

Unit	**Description**	**Duration** h
1.	**Ordinary Differential Equations**: Euler's and Runge-Kutta Methods, Multi step Methods: - explicit Adams–Bashforth technique & Implicit Adams – Moulton Technique.	**6**
2.	**Partial Differential Equations** Explicit and Implicit finite difference scheme, Stability of finite difference method, Applications of finite difference analysis in boundary value problems, one dimensional diffusion equation, Wave equation, Laplace equation.	**6**
3.	**Calculus of Variation** Introduction, Functional, Euler's equation, Isoperimetric Problem, Functional involving higher order derivative, Approximate solution of boundary value problem, Rayleigh –Ritz method, Galerkin's method, Lagrange's principal.	**6**
4.	**Finite Element Method:** Introduction to FEM, exact solution vs approximate solution, principle of FEM, general procedure for finite element analysis, Discretization process, Solution of Initial and boundary value problem using FEM (For one Dimension).	**6**
5.	**Numerical Computation of Eigen Values and Eigen Vectors** Faddeev-Laeverrier's method, Power method, Householder method, Given's method	**6**
6.	**Pseudo Analytical Techniques**: Laplace transform, Inverse Laplace transform, Solution of differential equations using Laplace Transform, Pseudo Analytical techniques (For the solution of Partial differential equation using pseudo linear principle)	**6**
	Total	**36**

Text Books:

1. Dr. B.S. Grewal, Numerical methods in Engineering and Science, Khanna Publishers, Eleventh Edition, 2013
2. M.K. Jain, F.R.K. Iyangar, Numerical methods for scientific and engineering computation, New Age International Publishers, Sixth Edition, 2012.

3. P Seshu, Text Book of Finite Element Analysis, Prentice-Hall of India Pvt. Ltd., New Delhi, 2007.
4. L. A. Pars, An Introduction to Calculus of Variations, Dover Publications, 2013.

Reference Books:

1. S. C Chapra, R. P Canale, Numerical Methods for Engineers, TMH, Fifth Edition,2005.
2. A. Constantinides, Applied Numerical Methods, McGraw Hill, 1988.
3. S. Chapra, Applied Numerical Methods with MATLAB, McGraw Hill, Third Edition, 2011.
4. M.K. Jain, Numerical Solution of Differential Equations, Wiley Eastern, 2nd Edition, 1984.
5. J.N.Reddy, An Introductory Finite Element Method, 3edition by McGraw-Hill Education, 2005.
6. Kielhöfer Hansjörg , Calculus of Variations, Springer, 2003.

Program:	M. Tech. Mechanical (Heat Power Engineering)	Semester : I
Course :	Air Conditioning System Design (Elective)	Code : MMH1502A

Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
3	3	3	20	30	50	100

Pre-requisite: Thermodynamics, Heat Transfer, Refrigeration & Air Conditioning

Objectives:

1. To understand and perform psychometric calculations of air conditioning processes
2. To familiarize the students with basics of thermal comfort so as to choose inside and outside design conditions
3. To be able to determine the heating/cooling load for a given building and thereby determine the size of air conditioning equipment.
4. Understand and demonstrate the procedure for sizing of air conditioning duct

Course Outcomes:

Student will be able to

1. Perform and evaluate basic psychometric calculations for load estimation for industrial and human comfort condition.
2. Select types of air conditioning system for different application.
3. Design compressor, evaporator, condenser and expansion valve of air conditioning system.
4. Design of ducting system for air distribution.
5. Analyze the air handling unit for different application.

Detailed Syllabus:

Unit	Description	Duration h
1.	**Psychrometry and Air Conditioning Load Estimation** Psychrometry: Basic Psychrometry and processes, BPF of coil, ADP, adiabatic mixing of two air streams, SHF, RSHF, GSHF, ESHF. Factors contributing to cooling load, Numerical based on load analysis.	6
2.	**Comfort Conditioning** Human Comfort Thermodynamics of human body, comfort and comfort chart, factors affecting human comfort, concept of infiltration and ventilation, indoor air quality requirements	4
3.	**Air Conditioning Systems** Air Conditioning Systems working of summer, winter and year-round AC systems, all air system, all water system, air water system, variable refrigerant flow and variable air volume systems, unitary and central air conditioning.	4
4.	**Components of Refrigeration and Air Conditioning Systems.** Working of reciprocating, centrifugal, screw and scroll compressors and compressor characteristic curves, operation envelope and maintenance required, working of air cooled, water cooled and evaporative condensers, working of DX, Flooded, Forced feed evaporators, Expansion devices – Capillary tube, TXV, EXV, operating and safety controls. Primary and secondary pump required in chiller plant, introduction to BMS and plant management	8
5.	**Air Distribution Systems** Ducts Classification of ducts, duct material, pressure in ducts, flow through duct, pressure losses in duct (friction losses, dynamic losses), air flow through simple duct system, equivalent diameter, Methods of duct system design: equal friction, velocity reduction, static regain method (numerical on duct system design)	6
6	**Air Handling Unit and Advances in Air Conditioning** Air handling unit schematic, AHU design, Fan coil unit, types of fans used in air conditioning, Evaporative air conditioning system, Desiccant based air conditioning system	8
	Total	36

Text Books

1. R.C. Arora, Refrigeration and Air conditioning, PHI Learning, 2012.
2. W. P. Jones, Air conditioning Applications and Design, Holder Arnold Publishers, 1973.
3. C P Arora, Refrigeration and Air conditioning, Tata McGraw Hill Publication, 2006.

Reference Books

1. F. C. McQuiston, J.D. Parker, J. D. Spitler, Heating, Ventilating and Air Conditioning: Analysis and Design, Wiley India Pvt. Limited, 2011.
2. R. McDowall, Fundamentals of HVAC systems, Elseveir, 2007.
3. J. F.Kredier, Handbook of Heating, Ventilation and Air Conditioning- CRC Prress, 2000.

Program:	M. Tech. Mechanical (Heat Power Engineering)		Semester: I			
Course:	Design of Solar and Wind Energy Systems (Elective)		Code: MMH1502B			
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
3	3	3	20	30	50	100

Pre-requisite: Thermodynamics, Fluid Mechanics, Heat Transfer, Mathematics

Objectives:

1. Demonstrate significance of analysis solar and Wind Resources Sources and design technologies of their Utilization
2. Enable the students to estimate the potential of solar and wind resources by through numerical assignments
3. Understand economics of Solar and Wind power plants
4. Expose them to conceptualize and design renewable energy appliances and equipment
5. Enable them to independently analyze, implement and asses the real-life systems
6. Develop a research insight about solar and wind energy technologies so as to motivate all concerned for enhanced deployment of renewable energy option

Outcomes:

After learning the course, the students should be able to:

1. Calculate basic performance parameters governing solar and wind power systems
2. Size solar PV system for off-grid power generation applications.
3. Apply/select proper type of wind/solar power/storage device as per end use requirement.
4. Design hybrid systems using solar and wind power

Detailed Syllabus:

Unit	Description	Duration, h
1.	**Solar Energy Resource** Solar Extraterrestrial Radiation, Spectral Distribution, Solar Geometry, solar radiation on tilted surface. Measurement of Solar Radiation.	4
2.	**Applications of Solar Thermal Energy**: - Low temperature applications - Flat Plate Collectors, Performance evaluation, applications, Testing and Standards, Medium and high temperature applications of Solar Thermal Energy – Concentrating collectors, classification, types and suitability, tracking of collector, Performance evaluation of point of focusing, line focusing collectors, Solar thermal power generation -technologies, Storage issues and challenges in the commercialization.	7
3.	**Solar Photovoltaic Conversion** Basic Semiconductor Physics, A generic photovoltaic cell, Modules and Arrays, Impact of Temperature and Shading on the performance of a PV module, Types of Solar Inverters, Solar System configurations, Balance of System (BoS), system design, Hybrid solar system. Design of SPV systems using PVSYsT.	7
4.	**Wind Power Systems** History and types of wind machines, Terminology, Dimensional analysis, Principles of Aerodynamics of wind turbine blade, Maximum rotor efficiency (Betz Limit), Power output from practical wind turbine generators, Concept of load matching.	6
5.	**Wind Resource analysis** Average power in wind, Wind speed statistics, Wind speed distribution, Wind shear, Wind measurement instrumentation, Wind data analysis, tabulation, Wind resource estimation	6
6.	**Wind turbine Generators, Control and hybrid systems** Generators and control systems, On-grid and off grid wind power plants, sizing of wind based off grid systems, wind-PV hybrid, wind-diesel hybrid. Demonstration on HOMER Pro.	6
	Total	36

Text Books:

S. P. Sukahtme, J. K. Nayak, Solar Energy Principles of Thermal Collection and Storage, Tata McGraw Hill, 2006

G. L.Johnson, Wind Energy Systems, Prentice Hall, New York, 1985.

J. R. Balfour, Introduction to Photovoltaic System Design, Jones & Bartlett Publishers, 2011

G. N. Tiwari and M. K. Ghosal Fundamentals of Renewable Energy Sources, by, Narosa Publishing House, 2007.

Reference Books:

J A. Duffie .and W.A. Beckman., Solar Engineering of Thermal Processes, John Wiley and Sons,Inc. Second Edition, 1991

G. Masters, Renewable and Efficient Power Systems, Wiley Inter-science, John Wiley and Sons. Inc. ,2004

H.P Garg., J Prakash., Solar energy Fundamentals and Applications, Tata Mc Graw Hill Publishing Company, New-Delhi, 2000.

V.V. N. Kishore, Editor, Renewable Energy Engineering and Technology, A knowledge Compendium, The Energy and Resources Institute, New Delhi, 2008

S. N. Bhadra, D. Kastha, S. Banerjee, Wind Electrical Systems, Oxford University Press, USA, 2005.

S. Mathew, Wind Energy: Fundamentals, Resource Analysis and Economics, Springer-Verlag Berlin Heidelberg, 2006.

Program:	**M. Tech. Mechanical (Heat Power Engineering)**			**Semester**	**I**	
Course :	**Gas Dynamics (Elective)**			**Code :**	**MH1502C**	
Teaching Scheme			**Evaluation Scheme**			
Lecture	**Hours**	**Credit**	**IE 1**	**IE 2**	**ETE**	**Total**
3	**3**	**3**	**20**	**30**	**50**	**100**

Pre-requisite: Fluid Mechanics, Thermodynamics and Heat Transfer

Objectives:

1. To analyze compressible flow through constant and variable area duct by applying principles of Fluid mechanics.
2. To understand and apply mathematical treatment to various problems related to Generalized quasi one-dimensional Flow, one-dimensional compressible flow
3. To study about the phenomenon of shock waves and its effect on flow

Outcomes: After learning the course, the students should be able to:

1. Apply governing equations to practical problems involving compressible fluid flow.
2. Analyze compressible flow having Normal shock by using different relations.
3. Apply governing equations to compressible flow through constant area duct with friction and flow through constant area duct with heat transfer.

Detailed Syllabus:

Unit	**Description**	**Duration, h**
1	Review of Fundamentals: Concepts from Fluid Mechanics, Basic Thermodynamic Relations, Compressible flow: Waves propagation, Steady one-dimensional compressible flow, Mach waves, Compression waves, Expansion waves Basic Flow features: Isentropic flow, Shock waves, Stationary and Moving Shocks, Oblique Shocks, Bow Shocks, Expansion Fans. Example flows: Flow around bodies, Shock expansion method for flow over airfoils.	**10**
2	Flow Through a nozzle: Convergent Nozzles, CD Nozzles, De-Laval nozzle, Exit Pressure variation vs Stagnation pressure variation.	**8**
3	Oblique shock wave reflections, Jet flows Under- and over-expanded flows Shear layers, Other Non-isentropic flows	**8**
4	Flow with Friction and Heat Transfer, The fanning equation, Friction factor and friction parameter, Fanno lines and Rayleigh lines, Fanno equations, Friction choking Flow with heat addition, Thermal choking	**10**
	Total	**36**

Text Books:

1. E. Rathkrishnan, “Gas Dynamics”, PHI Learning, 2017.
2. P.Balchandran, “Fundamentals of Compressible fluid Dynamics”, PHI Learning, 2006.

Reference Books:

1. R.D. Zucker and B. Oscar, “Introduction to Gas Dynamics”, John Wiley and Sons. Inc.,2002.
2. A. H. Shapiro, “Dynamics and Thermodynamics of Compressible Fluid Flow”, MIT Press,1953.
3. A.J. Chapman and W.F Walker. Introductory Gas Dynamics Holt, Reinhart and Winston, Inc. NY, USA.,1971

PROFESSIONAL ELECTIVE LAB-I (ELECTIVE I & II)						
Program:	**M. Tech. Mechanical (Heat Power Engineering)**			**Semester:**	**I**	
Course :	**Professional Elective Lab. 1 (EL1 & ELII)**			**Code:**	**MMH1503**	
Teaching Scheme			**Evaluation Scheme**			
Practical	**Hours**	**Credit**	**TW**	**PR**	**OR**	**Total**
2	**2**	**1**	**50**	**--**	**50**	**50**

Guidelines:

1. Any one subject from Part A and Part B as per students' elective choices
2. Total experiments to be conducted are Three from Part A and Three from Part B
3. Total : 6 experiments/assignments in 12 hours

Detailed Syllabus:

Part A: Elective 1- Refrigeration& Cryogenics (ANY Three)

Expt.	Description	Duration h
1.	Test on Multi-pressure system Test Rig.	2
2.	Test on Cascade Refrigeration system Test Rig.	2
3.	Test on Heat Pump Test Rig.	2
4.	Analysis of Refrigeration systems using Cool Pack software.	2
5.	Visit to Cryogenic Refrigeration Plant.	2
6.	To design Vapour Compression refrigeration system for cold storage plant	2
	Total	**06**

Part A: Elective 1- Energy Conservation & Management (ANY Three)

Expt.	Description	Duration h
1.	Energy audit of air conditioner	2
2.	Determination of lux intensity of different lighting sources	2
3.	Case study of Energy use in Commercial Buildings	2
4.	Boiler performance trials and troubleshooting remedies (Industry based)	2
5.	Report on Lighting systems and fittings and advances in electrical fittings	2
6.	Visit to Electric Power substation	2
7.	Visit to Boiler /waste heat recovery plants	2
	Total	**06**

Part A: Elective 1- Advanced Mathematics (ANY Three)

Expt.	Description	Duration h
	List of Experiments:	2
1	Make a program of Adam's bashforth method with its flow chart.	2
2	Solution of Difference Equations using Euler Method.	2
3	Solution of differential equation using 4th order Runge- Kutta method.	2
4	To find the numerical solution of Laplace Equation.	2
5	To find the numerical solution of Wave Equation.	2
6	To find the numerical solution of Heat Equation.	2
7	To find solution of boundary value problem using Rayleigh –Ritz method,/Galerkin's method/FEM.	2
	Total	**06**

Part B: Elective 2- Air-Conditioning System Design (ANY Three)		
Expt.	**Description**	**Duration h**
1.	Heating and cooling load estimation for Hospital / Restaurant / Commercial building / Supermarkets etc. any one application using standard commercially available software.	**2**
2.	Design of Air Conditioning system for Hospital / Restaurant / Commercial building / Supermarkets and Select suitable Air Conditioning Equipment for the design (Compressor, Condenser, Expansion device, Evaporator, Fan, Cooling coil, Pumps, etc).	**2**
3.	Case study on Desiccant Dehumidification	**2**
4.	Case study on Evaporative cooling	**2**
5.	Case study on Chilled beams or Displacement Ventilation	**2**
	Total	**06**
Part B: Elective 2- Design of Solar and Wind Systems (ANY Three)		
Expt.	**Description**	**Duration h**
1.	Design of photovoltaic plant for Stand-alone applications	**2**
2.	Design of photovoltaic plant for on-grid applications PVSYST	**2**
3.	Wind resource analysis of a prospective site	**2**
4.	Design of a Hybrid System on HOMER Pro.	**2**
5	Visit to a Solar Power Plant / Wind Power Plant	
	Total	**06**
	Part B: Elective 2- Gas Dynamics (ANY Three)	
1	Shock Tube Problem (Riemann Problem)	**2**
2.	Numerical on oblique shock wave	**2**
3.	Numerical on Flow with heat addition	**2**
4.	Analytical or numerical simulation of flow through convergent divergent nozzle. For numerical solution use any commercial or open-source software or programming language	**2**
	Total	**06**

SKILL DEVELOPMENT LAB-1						
Program: M.Tech (Heat Power Engineering)					**Semester:** I	
Course : Skill Development Lab-I					**Code:** MMH1503	
Teaching Scheme			**Evaluation Scheme**			
Practical	**Hours**	**Credit**	**TW**	**PR**	**OR**	**Total**
2	**2**	**1**	**50**	**--**	**50**	**100**

Pre-requisite: Programming languages**,** Hands on experience on commercial software like MATLAB, CATIA, 3DExperience, Ansys, Adams, etc advisable.

Objectives:

The objective of this certificate curriculum is to

1. Competency building among students
2. Provide participants with a basic knowledge of CFD which will help them to work competently in both an industrial setting and in further graduate studies involving CFD and its applications.

Outcomes:

After learning the course, the students should be able to:

1. Enhancing skillsets of numerical analytic techniques and proficiency in applying these to solve advanced multi-disciplinary problems involving fluid mechanics and related transport process phenomena.
2. Proficiency in analyzing fluid flow problems and assessing the appropriate CFD techniques for practical applications.

Guidelines :

1. Total experiments to be conducted are Six out of eight
2. **Total : 6 experiments 12 hours**

Detailed Syllabus:

Skill Development Lab (ANY Six)

1) It is recommended to use any programming language or commercial / open-source programming tool to write the program for practicals 1 to 4. The governing equations can be coded in using suitable discretization method like **Finite Difference Method** or **Finite Volume Method**. Write any three programs from 1 to 4 practicals.
2) For practicals 5 to 8, students can use any commercial software or open-source tool like OpenFOAM. Solve any three case studies from 5 to 8 practicals using suitable CFD software tool.

Expt.	Description	Duration, h
1	Two-dimensional steady state conduction equation.	**2**
2	Two-dimensional unsteady state conduction.	**2**
3	One-dimensional wave equation.	**2**
4	One-dimensional conduction convection problem.	**2**
5	Generate the grids for complex geometry for following cases. a) Create the structured grid for internal flows for complex geometry b) Create the unstructured grid for external flows for complex geometry	**2**
6	Numerical simulation of the flow over circular cylinder for various Reynolds number. Validation of results with published literature.	**2**
7	Suitable case study to study the boundary layer phenomena.	**2**
8	Aerodynamic analysis of an Ahmed Body	**2**
	Total	**12**

Course Syllabus
Semester-II

Program:	M. Tech. Mechanical (Heat Power Engineering)		Semester: II			
Course:	Advanced Heat Transfer		Code : MMH2405			
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
3	3	3	20	30	50	100

Pre-requisite: Engineering Mathematics; Fluid Mechanics; Heat Transfer

Objectives:

1. To develop an in-depth understanding of the physical processes involved in the transfer of thermal energy in the engineering applications.
2. To develop skills in the use of analytical techniques for complex thermal systems, by using constitutive equations, empirical correlations and the energy conservation principle.
3. To understand the need for optimization and different techniques involved
4. To analyze radiation heat transfer problems of various thermal systems

Outcomes:

After learning the course, the students should be able to:

1. Analyze the analytical and numerical solutions for heat conduction problems of real-life Thermal systems
2. Analyze and evaluate critically thermal radiation heat transport and formulate complex thermal networks for two or more radiating surfaces.
3. Solve momentum and energy equation mathematically for convective heat transfer.
4. Discriminate, synthesize and evaluate natural convection heat transfer problems encountered in real life applications.
5. Discriminate, synthesize and evaluate forced convection heat transfer problems encountered in real life applications.
6. Differentiate the different flow regimes occurred in flow boiling under forced convection and able to solve the practical problem on condensation

Detailed Syllabus:

Unit	Description	Duration, h
1.	**Conduction:** General heat Conduction equation-initial and boundary conditions. Transient heat conduction: Lumped system analysis, Heisler charts, semi-infinite solid, use of shape factors in conduction-2D transient heat conduction-product solutions. 1D & 2D steady state and simple transient heat conduction problems-implicit and explicit methods.	8
2.	**Radiation** Radiant heat exchange in grey, non-grey bodies, with transmitting. Reflecting and absorbing media, specular surfaces, gas radiation, radiation from flames.	06
3.	**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.	6
4.	**Natural Convection** Approximate analysis on laminar free convective heat transfer, Boussinesque approximation, different geometries-combined free and forced convection.	6
5.	**Forced Convection** 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. 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.	6
6.	**Boiling and Condensation:** Forced convection boiling. Two phase flow film condensation in horizontal tubes, on banks of tubes, Dropwise condensation correlations (No derivation)	04
	Total	36

Text Books:

1. T. L. Bergman, A. S. Lavine, F. P. Incropera, D. P. DeWitt, Fundamentals of Heat and Mass Transfer, Wiley, 2011.
2. Y. Cengel, A. Ghajar, Heat and Mass Transfer, Tata Mc Graw Hill, 2011.
3. M.N. Ozisik, Heat transfer - A Basic approach, Mc Graw Hill Int., 1985.
4. Convective Heat transfer, A Bejan, John Wiley and sons, 2013.

Reference Books:

1. J.P. Holman, Heat Transfer, Mc Graw Hill, 2002.
2. S.P. Sukhatme, Heat transfer, University Press, 2005.
3. J. Welty, G. L. Rorrer, D. Foster, Fundamentals of Momentum, Heat and Mass Transfer Wiley, 2014.

Program:	M. Tech. Mechanical (Heat Power Engineering)		Semester: II			
Course:	Computational Fluid Dynamics		Code : MMH2406			
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
3	3	3	20	30	50	100

Pre-requisite: Fluid Mechanics, Thermodynamics, Heat Transfer, Viscous Flow Theory

Objectives:

1. Students will be able to understand the basics of conservation laws and transport mechanisms of fluid-dynamics and numerical methods used for obtaining solution and calculation of engineering-parameters in CFD.
2. Algebraic formulation: develop the ability to do discretization by finite volume method.
3. CFD development: develop programming skills by in-house code development for conduction, convection or fluid dynamics problems.
4. CFD application and analysis: Learn to apply the code on various problems in fluid dynamics and heat-transfer; and analyze as well as discuss the results.

Outcomes:

After learning the course,

1. Apply suitable discretization technique to governing equations and convert into algebraic equations
2. Analyze the problem in fluid mechanics and heat transfer and mathematically model it
3. Develop an algorithm to solve the governing equations in CFD.
4. Create geometric model for real life application in an engineering domain.

Detailed Syllabus:

Unit	Description	Duration, h
1	**Introduction** Introduction to CFD: What is CFD?, Why to study CFD?, CFD analysis process: development, application and analysis. Essentials of Fluid-Mechanics and Heat-Transfer: Conservation and subsidiary laws, transport mechanisms, and differential formulation from the conservation laws, Brief introduction of ODE (IVP and BVP) and PDE, classification of PDE.	6
2	**Essentials of Numerical Methods** Finite Difference Method (FDM), FDM based algebraic-formulation for 1D and 2D steady state heat conduction, iterative solution of system of linear algebraic equations, Initial and Boundary conditions, various methods to solve PDE numerically along with their advantages and disadvantages.	6
3	**Discretization Techniques: Finite Volume Method** Discretization Methods, Discretization procedure in Finite-volume framework. Approximation of Surface Integrals, Approximation of Volume Integrals, explicit based solution-methodology for 1D system, upwind schemes.	6
4	**Computational Heat-Transfer on a Cartesian-Geometry** Applications of Finite Volume Methods: One-dimensional and two-dimensional steady and unsteady state diffusion equation, steady state one-dimensional convection and diffusion, stability analysis, explicit and implicit method based solution-methodology.	6
5.	**Numerical Solution to Navier – Stokes Equation** Finite Volume Method (FVM) based algebraic-formulation for convection-diffusion problems, assessment of the central differencing scheme. Pressure correction technique, staggered grids, SIMPLE algorithm.	6
6	**Introduction to Turbulence Modeling** Introduction to turbulence models, Reynolds Averaged Navier-Stokes equations (RANS), One equation model (Derivation) and two equation model.	6
	Total	36

Text Books:

1. J. D. Anderson, Computational Fluid Dynamics, McGraw Hill, 1995
2. A. Sharma, Introduction to Computational Fluid Dynamics, Athena Academic and John Wiley & Sons, UK, 2017.
3. A. W. Date Introduction to Computational Fluid Dynamics, Cambridge Univ. Press, USA, 2009.
4. Versteeg, H.K. and Malalasekera W. An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Longman Scientific & Technical, Harlow, 1995.
5. T. J. Chung, Computational Fluid Dynamics, Cambridge University Press, 2010.
6. S.V. Patankar, Numerical Heat Transfer and Fluid Flow, Hemisphere Publishing Corporation, New York, 1980.
7. K. Muralidhar, and T. Sundarajan, (Editors) Computational Fluid Flow and Heat Transfer (2nd ed.), IIT Kanpur Series, Narosa Publishing House, New Delhi, 2003.
8. J.H. Ferziger, and M. Peric Computational Methods for Fluid Dynamics, Springer Verlag, Berlin, 2002.

Reference Books:

1. D.C. Wilcox, Turbulence modeling for CFD, DCW Industries, La Canada, CA, 3rd Ed., 2006.
2. C. Hirsch, Numerical Computation of Internal and External Flows - The Fundamentals of Computational Fluid Dynamics, Butterworth-Heinemann, 2007
3. G. Biswas and V. Eswaran, Turbulent Flows: Fundamentals, Experiments and Modeling, Narosa Publishing House, 2002.

PROFESSIONAL CORE LAB - II						
Program: M.Tech. Mechanical (Heat Power Engineering)				**Semester: II**		
Course: Professional Core Lab-II (AHT & CFD)				**Code: MMH2407**		
Teaching Scheme			**Evaluation Scheme**			
Practical	**Hours**	**Credit**	**TW**	**PR**	**OR**	**Total**
2	**2**	**1**	**50**	**--**	**50**	**50**

Guidelines:

1. Total experiments to be conducted are Three from Part A and Three from Part B
2. Total: 6 experiments 12 hours

Detailed Syllabus:

Part A: Core Subject 1 (ANY Three)

Expt.	Description	Duration, h
1.	Geometry Creation and Meshing using any commercial CFD software, CFD modeling for internal and external flows. Solve any three case studies from following list. 1) Laminar Pipe Flow & Turbulent Pipe Flow 2) Supersonic Flow over a Wedge 3) Compressible Flow in a Nozzle 4) Airfoil Analysis 5) Compressible Flow over a Flat Plate	**06**
	Total (Any three)	**06**

Part B: Core Subject 2 (ANY Three)

Expt.	Description	Duration, h
2.	Solve any three from the list of following six experiments 1. Transient Heat Conduction using Heisler and Grober charts for real life applications 2. Numerical method in heat conduction & convection. 3. Combined Natural and Forced Convection heat transfer. 4. Radiation Heat Transfer in Two Surface Enclosures 5. Assignment on Heat transfer augmentation techniques. 6. Numerical analysis of industrial problem on conduction/convection/radiation by using any modeling and analysis software.	**6**
	Total (Any three)	**06**

Program:	M. Tech. Mechanical (Heat Power Engineering)	Semester: II
Course:	Building Energy Systems & Technology (Elective)	Code : MMH2504A

Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
3	3	3	20	30	50	100

Pre-requisite: Refrigeration and Air Conditioning

Objectives:

1. To develop a multidisciplinary approach to the energy supply and use in new and existing buildings
2. To develop knowledge and understanding of system solutions that provide optimal indoor environment in buildings in an environmentally and cost-effective way
3. To create awareness of different building rating tools

Outcomes:

After learning the course, the students should be able to:

1. Should be able to identify features of an energy efficient building system
2. Learner should be able to apply simulation programs of buildings to perform energy calculations, evaluate the relationship between energy use, indoor comfort
3. Learner should be able to evaluate and justify energy-saving measures in existing building on the basis of engineering and economic feasibility
4. Learner should be able to apply the principles of energy management to obtain buildings that can be certified

Detailed Syllabus:

Unit	Description	Duration, h
1.	**Aspects of efficient building design** Solar geometry, climate responsive building design, Solar passive features Fundamentals of building acoustics, Quality indicators, Acoustic materials, Noise control, Effective day lighting design, Daylight Simulation, Thermal comfort, requirements of ASHARE standard 55	6
2.	**Design of Building systems** Mechanical systems design - heating cooling load calculations, comparison of software, energy simulation, Introduction Electrical systems design, Introduction to plumbing systems design, Other energy sources (DG Sets, Solar PV, Solar thermal) Integrated building design, introduction to BIM	6
3	**High Performance Building Systems** Introduction to high performing buildings, Methods and tools - rating systems (like LEED), Synergies between IAQ and energy efficiency, HVAC Controls, Protocols, overview of building management systems, New trends: IoT, data analytics, Fault detection & diagnostics	6
4	**Building energy codes** Overview of energy standards viz. ASHRAE 90.1, ECBC, IECC Understand compliance options and procedures for energy simulation Overview and application of energy codes in various green building rating systems viz. LEED, IGBC, GRIHA, etc. ,ECBC implementation in India and incentive programs	6
5	**Energy performance analysis of buildings** ASHRAE Level 1,2,3 energy audits, Commissioning of building systems, measurement and verification (IPMVP),Benchmarking tools such as energy star portfolio manager, Eco-Niwas Samhita, ASHRAE Building EQ	3
6	**Building Energy Simulations** Introduction, Overview of software and simulation engines, Introduction to eQuest Energy modeling inputs, reviewing data, quality control process, note making and assumptions, Energy simulation for design optimization, code compliance, benchmarking, and calibration, Best practices for energy simulation experts, professional certifications and credentials	9
	Total	**36**

Text Books:

1. N. K. Bansal, G Hauser, G. Minke, Passive building design: A handbook of Natural climatic control, Elsevier Science Ltd, 1994.
2. Manual on solar passive architecture: energy systems Engineering, IIT Delhi and Solar Energy Centre, Ministry of Non-conventional Energy Sources, Government of India, New Delhi
3. K. Sasikumar, S. Gopi Krishna Solid Waste Management, PHI (EEE) , 2013.
4. D. J. Harris, A Guide to Energy Management in Buildings, Spoon Press Energy Efficiency, Routledge; 1st edition ,2011.
5. M. Yang, X. Yu, Benefits for Environment and Society, Green Energy and Technology, Springer, 2015.

Reference Books:

1. Uses of landscaping for energy conservation Giani, Florida: Department of Physical Sciences, Florida International University
2. TERI report 96RT__ Window design optimisation
3. E. Mazria, The Passive Solar Energy book, Rodale Press, Pennsylvania, 1979
4. M. E Levy, D. Evans and C. Gardstein, The Passive Solar Construction Handbook, Rodale Press, Pennsylvania, 1983.
5. MIT Building Systems Design Handbook, Version 1.2 (Building Components)
6. MEP Databook Hardcover Sidney M. Levy
7. eQuest resources from doe2.com
8. ASHRAE Standard 90.1-2010, 2016
9. Green building rating system manuals – IGBC, LEED V4 BD+C, GRIHA V2015
10. Energy Conservation Building Code (ECBC) 2017
11. International Performance Measurement and Verification Protocol (IPMVP), NREL
12. ASHRAE Guideline 0 – The Commissioning Process and ASHRAE Standard 202
13. ASHRAE Technical Articles, research papers and case studies on relevant topics
14. IEA (International Energy Agency) – Building Optimization and Fault Diagnosis Source Book (IEA ANNEX 25)
15. Energy Efficiency Guide for Existing Commercial Buildings – The Business case for Building Owners and Managers – Dennis Landsberg, Mychele Lord, Steve Carlson, Fredric Goldner – ASHRAE / AIA / IESNA / USGBC

Program:	M. Tech. Mechanical (Heat Power Engineering)		Semester: II			
Course:	Thermal & Electrical Energy Storage (Elective)		Code : MMH2504B			
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
3	3	3	20	30	50	100

Pre-requisite: Basic knowledge in Electro-chemistry, Chemistry, DC electricity, Electronics, Power-Electronics

Objectives:

1. To understand the application, operating principle, performance criteria, failure modes, safety & precautions for various electrical & thermal energy storage systems.
2. To understand importance of monitoring critical parameters in various energy storage systems & applications for designing related control devices & systems.
3. To be able to illustrate the parameters affecting the selection, sizing, efficiency, life & operating safety of thermal & electrical energy storage devices
4. To enable the learner to design an energy storage system for given application with commercial costing & cost & benefit analysis in comparison with competing system

Outcomes:

After learning the course, the students should be able to:

1. Illustrate parameters affecting the selection and sizing of thermal energy storage devices.
2. Demonstrate understanding of operation of common types of rechargeable batteries and interpretation of results for design of battery & electronic controls
3. Measure, calculate & compare the energy density and capacity of batteries.
4. Optimally size batteries for electric vehicles, solar farms, UPS systems etc.
5. Design the battery & related AC/DC systems, prepare system specifications for different industrial and consumer product applications for best performance, life, energy & optimum investment cum operating economy.

Detailed Syllabus:

Unit	Description	Duration, h
1.	**Thermal energy storage** Load curve, basic principle of energy storage, types of energy storage systems. **Sensible thermal energy storage**- well-mixed tank, stratified tank, packed bed storage, operational characteristics, sizing. **Latent thermal storage:** operational characteristics, material selection, Heat exchange arrangement and containment of PCM, thermal cycling of PCMs.	**7**
2.	**Introduction to electric storage batteries:** Cells and Batteries: Operating theory, Components, classification, operation and reactions, parameters: S.O.C, D.O.D, voltage – open circuit/ on-load/ On-Charge/ Top of Charge, specific gravity, Internal Resistance, specific energy and energy density. Materials and Methods of manufacture - electrodes. electrolyte, containers, separators & others	**6**
3.	**Battery Types:** Detailed Study on Lead Acid, Advanced Lead Acid, Lithium Ion Batteries. Basics: Alkaline, Flow, Metal-air batteries.	**4**
4.	**Battery performance, operation and sizing** Charge- discharge characteristics, Ah efficiency, watt-hour efficiency, SOC & DOD, temperature dependence of battery capacity. Variables affecting battery performance/efficiency/life, cycling performance, operation and maintenance procedures, concept of Boost/Trickle/float/taper/ CC-CV & equalizing charge, types of battery chargers. With Practical Demo & hands on in Solar/ Battery Laboratory	**6**
5.	**Application based design** **Design for solar applications**: Off Grid Solar Array & Battery Selection, Design & sizing, Charge controller types relating to battery cycling performance and life. Operation & maintenance procedures **Design for EV applications:** Designing battery type & capacity for electric vehicle applications – namely Electric 2 & 3 wheelers.	**6**
6.	**Basic Knowledge on Batteries in important Applications:** Stationary or Standby power- Power stations/ sub-stations/ Solar & wind Power/ Process Industries/ Data Centers/ Telecom/ UPS/ Inverters	**7**

	Traction or motive power batteries – Electric Fork & Tow Trucks, EVs, Train lighting & air-conditioning, Starting, lighting and ignition (automotive) batteries – Cars, LCV, HCV & 2/3 wheeler starting batteries Overview-Battery management systems including thermal management	
	Total	**36**

Text Books:

1. I. Dincer and M. A. Rosen, Thermal Energy Storage – Systems and Applications, Wiley Publication, 2002.
2. D. Pavlov, Lead Acid Batteries – Science & Technology, Elsevier, 2017.
3. D. Linden and T. Reddy, Handbook of batteries, .2002
4. Thomas P J Crompton, Battery Reference Book, Elsevier, 2000.
5. Joey Jung, Lei Zhang , Jiujun Zhang 'Lead-Acid Battery Technologies: Fundamentals, Materials, and Applications' CRC Press , 1st edition, June 2015.
6. J. Li, S. Zhou, Yehui Han, Advances in Battery Manufacturing, Service, and Management Systems, John Wiley & Sons, 2016.

Reference Books:

1. J. Eyer, G. Corey, Energy Storage for the Electricity Grid: Benefits and Market Potential Assessment Guide, Report, Sandia National Laboratories, Feb 2010.

Program:	M. Tech. Mechanical (Heat Power Engineering)		Semester II			
Course :	Combustion in IC Engines & Emission Controls (Elective)		Code : MMH2504C			
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
3	3	3	20	30	50	100

Pre-requisite: Engineering Thermodynamics, Basic course on IC engines

Objectives: The students will be able to

1. Learn the normal and abnormal combustion in SI and CI engines
2. Understand the formation of emissions in engines
3. Get insight about the effect of engine design and operating variables on engine emission
4. Learn various engine emission measurements
5. Familiar with various emission control methods

Outcomes: After learning the course, the students will be able to

1. Analyze the abnormal combustion in SI & CI engine
2. Analyze the emission formation sources in engines
3. Analyze engine design parameters and operating variables which affect emission
4. Apply the knowledge engine emission measurement methods for measurement of emissions
5. Apply the knowledge engine emission control methods to reduce emissions

Detailed Syllabus

Unit	Description	Duration, h
1.	**Combustion in SI and CI engine:** Normal combustion in SI and CI engine, factors affecting combustion in SI and CI engine, Detonation and knocking	6
2.	**Formation of engine emissions:** Engine emissions and its formation, formation of NOx in SI and CI engine, formation of CO in SI engine, formation of HC in SI and CI engine, soot and PM formation	6
3.	**Effect of engine design and operating variables on emission:** Factors which affect emissions: Compression ratio, ignition timing, AF ratio, residual gas and EGR, engine load and speed, coolant temperature	6
4.	**Engine emission measurement:** Emission test procedure, emission standards, emission measurement: CO and CO_2 NDIR analyzer, Fame Ionization detector, Chemiluminescence analyzer, smoke meter, PM measurement	6
5.	**Emission control in SI and CI engine:** Add-on system for engine emission control, engine exhaust after treatment, catalytic convertor, diesel exhaust after treatment, diesel particulate filters, crankcase blowby emission control, EGR.	6
6.	**Advanced engine combustion systems:** Stratified charge engine, HCCI, CAI engine, HCCI diesel engine, GDI engine, Engine electronics.	6
	Total	36

Text Books:

1. J.B. Heywood, Internal combustion engine Fundamentals, McGraw Hill
2. B.P. Pundir, Engine Emissions: Pollutant Formation and Advances in Control Technology, Narosa publications

Reference Books:

1. Handbook of Air Pollution from Internal Combustion Engines: Pollutant Formation and Control, Ed. Eran Sher, Academic Press, 1998.
2. Internal Combustion Engine Handbook, Ed. Richard Van Basshuysen and Fred Schafer, SAE International, 2004
3. C.R. Ferguson, A. T. Kirkpatrick, Internal. Combustion Engines, 2nd Edition, John Wiley & Sons, 2001.

Program:	M. Tech. Mechanical (Heat Power Engineering)		Semester: II			
Course:	Design of Thermal Systems (Elective)		Code : MMH2505A			
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
3	3	3	20	30	50	100

Pre-requisite: Engineering Mathematics, Thermodynamics, Fluid Mechanics, Heat Transfer

Objectives:

1. To develop mathematical models of phenomena involved in thermal sciences
2. To introduce simulation as a tool for problem solving
3. To understand the need for optimization and different techniques involved
4. Appreciate the application of modeling, simulation and optimization in thermal equipment design

Outcomes:

After learning the course, the students should be able to:

1. Create models of applied thermodynamics and heat transfer such as heat exchangers, evaporators, condens condensation of binary mixtures and turbo machinery
2. Able to constructing the simulation of thermal systems
3. Select optimization variables and perform basic of optimum system design
4. To be able to solve real world problems using principles of modeling, simulation and optimization

Detailed Syllabus:

Unit	Description	Duration, h
1	**Basic Considerations in Thermal System Design** Thermal Systems- Types and Examples, Formulation of the Design Problem, Steps in the Design Process	6
2	**Modeling of thermal systems** Importance of Modeling in Design, Basic Features of Modeling, Types of Models, Mathematical Modeling, Physical Modeling and Dimensional Analysis, Curve Fitting	6
3	**Numerical Modeling** Development of a Numerical Model and solution methods, Linear Algebraic Systems, Nonlinear Algebraic Systems, Ordinary Differential Equations, Partial Differential Equations, Numerical Model for a System, Modeling of Individual Components, Merging of Different Models, Accuracy and Validation	6
4	**System Simulation** Importance of Simulation, Different Classes, Flow of Information, Methods for Numerical Simulation, Steady Lumped, Dynamic Simulation of Lumped, Distributed System, Simulation of Large System, Numerical Simulation Versus Real System	6
5	**Optimization** Objectives/constraints, problem formulation. Unconstrained problems- Necessary & Sufficiency conditions. Constrained Optimization- Lagrange multipliers, constrained variations, Kuhn-Tucker conditions. Linear Programming - Simplex tableau, pivoting, sensitivity analysis. Dynamic Programming. Search Techniques- Univariate / Multivariate.	6
6	**Case Studies in Optimum Design** Case studies of optimization in Energy systems problems. Dealing with uncertainty- probabilistic techniques**.** Case study on piping systems – systems in series and parallel, losses Case study on heat exchanger design- Case study on Pumps/Fans/Compressors	6
	Total	36

Text Books:

1. W. F. Stoecker, Design of Thermal Systems, Mcgraw Hill, 1981.
2. S.S.Rao, Optimisation theory and applications, Wiley Eastern, 1990.
3. C.Balaji, Essentials of Thermal System Design and Optimization, New Delhi in India and CRC Press, 2018.
4. Y.Jaluria, Design and optimization of thermal systems,, Mc Graw Hill, 1998.

Reference Books:

1. L.C. Burmeister, Elements of thermal fluid system design, Prentice Hall, 1998.
2. S.S. Sastry Introductory methods of numerical analysis, Prentice Hall, 1988
3. J.S. Arora, Introduction to optimum design, Mc Graw Hill, 1989.
4. K. Deb Optimization for engineering design - algorithms and examples,Prentice Hall, 1995.

Program:	M. Tech. Mechanical (Heat Power Engineering)		Semester : II			
Course:	Turbulent Flow (Elective)		Code : MMH2505B			
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
3	3	3	20	30	50	100

Pre-requisite: Fluid Mechanics, Thermodynamics, Heat Transfer, Viscous Flow Theory

Objectives:

1. To understand fundamentals of turbulent flows and the stochastic and chaotic nature of turbulence.
2. To familiarize the students with the statistical theories of turbulence.
3. To provide the students with the tools for modeling turbulent flows.
4. To familiarize the student with simulation techniques in turbulent flows.
5. To familiarize the students with applications of turbulence in industry and environment.

Outcomes: After learning the course,

1. Students will become familiar with fundamental physics of turbulent flows, transport of moment, energy and vorticity in turbulent flows.
2. Students will be able to analyze simple shear, wall bounded and boundary layer flows with the use of suitable models of turbulence.
3. Students will be able to analyze turbulent flows in complex regions with the use of open source or commercial software or codes.

Detailed Syllabus:

Unit	Description	Duration, h
1	**Physics of Turbulent Flow** Definition of turbulence, nature of turbulent flows: irregularity, diffusivity, dissipation, wide spectrum, high Reynolds number, rotational, dissipative, continuum phenomenon. Characterization of turbulent flows – statistical averages, moments, probability density function, correlation, spectrum, eddy motions and length scales.	6
2	**Transport of Moment and Heat in Turbulent Flows** Reynolds averaged Navier Stokes (RANS) Equations, turbulent stresses, mean and turbulent kinetic energy, energy transfer in turbulent flows, Closure problem, Boundary layer equations for turbulent flows, momentum integral equation for turbulent boundary layer, vortex stretching, mixing-length model.	6
3	**Statistical Description of Turbulence** Random nature of turbulence, distribution function, probability density, moments, correlations, Taylor's hypothesis, integral micro scales, homogeneous and isotropic turbulence, Kolmogorov hypothesis, scales of turbulence, energy cascade, and turbulence spectra.	6
4	**Free Shear Flows** Mixing layer theory, Turbulent wakes, and jets. Grid generated turbulence and its applications.	6
5	**Wall-Bounded Turbulent Flows** Flow-through channel and pipes. Turbulent boundary layer, various near-wall laws. Turbulent structures (flow visualization).	6
6	**Computational Modeling of Turbulence and Experimental Techniques** Introduction - approaches to prediction of turbulent flows, eddy-viscosity hypothesis, algebraic model, one and two equation models of turbulence, k-ε and k-ω model, Reynolds-stress model, near-wall treatment, Introduction to LES and DNS.	6
	Total	36

Text Books:

1. G. Biswas and V. Eswaran, Turbulent Flows: Fundamentals, Experiments and Modeling, Narosa Publishing House, 2002.
2. S. B. Pope, “Turbulent Flows”, Cambridge University Press, 2000.
3. H. Tennekes and J. L. Lumley, “A First Course in Turbulence”, MIT Press, 1972.
4. Cebeci. T, ‘Modeling and computation of turbulent flows”, Elsevier, Amsterdam, 2003.

Reference Books:

1. D.C. Wilcox, "Turbulence modeling for CFD", DCW Industries, La Canada, CA, 3rd edition 2006.
2. P .A. Durbin, and B.A. Reif Paterson. "Statistical theory and modelling for turbulent flows", 2nd ed. John Wiley, Chichester, U.K, 2011.
3. K. Hanjalic, and B. Launder, “Modelling of turbulence in engineering and environment – Second moment route to closure” Cambridge University Press, Cambridge, U.K., 2013.

Program:	M. Tech. Mechanical (Heat Power Engineering)		Semester: II			
Course:	Two Phase Flow (Elective)		Code : MMH2505C			
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
3	3	3	20	30	50	100

Pre-requisite: Mathematics, Engineering Thermodynamics, Heat Transfer

Objectives: The students will be able to

1. Learn basic terminologies of two-phase flow.
2. Get insight about two phase flow regimes I
3. Get familiar with two phase flow modeling.
4. Get insight about two phase flow regimes II
5. To understand pressure, drop in two phase flow

Outcomes:

After learning the course, the students will be able to

1. analyze the two-phase interfacial phenomenon
2. analyze the various flow regimes
3. apply suitable model to any two phase flow
4. evaluate the pressure drop in two phase flow

Detailed Syllabus

Unit	Description	Duration, h
1.	**Introduction to two-phase flow:** Single-Phase Flow Fundamentals, States of Matter and Phase Diagrams for Pure Substances, Transport Equations, Single-Phase Multicomponent Mixtures, Phase Diagrams for Binary Systems, Gas-Liquid Interfacial Phenomena: Surface Tension and Contact Angle, Thermo-capillary Effect, Liquid-Vapor Interphase at Equilibrium, Interfacial Mass Transfer. Introduction of two phase mixtures	6
2.	**Two phase flow regimes I:** Two-Phase Flow Regimes in Adiabatic Pipe Flow: Vertical, Co-current, Upward Flow, Co-current Horizontal Flow. Flow Regime Maps for Pipe Flow, Two-Phase Flow Regimes in Vertical Rod Bundles	6
3.	**Two phase flow modeling I:** Two-Phase Flow Models, One-Dimensional Homogeneous-Equilibrium Model: Single-Component Fluid, One-dimensional Homogeneous-Equilibrium Model: Two-Component Mixture	6
4.	**Two phase flow modeling II:** One-Dimensional Separated Flow model: Single-Component Fluid, One-Dimensional Separated-Flow Model: Two-Component Fluid, Drift flux model	6
5.	**Two phase flow regimes II:** Upward, Co-current Flow in Vertical Tubes, Co-current Flow in a Near-Horizontal Tube, Two-Phase Flow in an Inclined Tube, Dynamic Flow Regime Models and Interfacial Surface Area.	6
6.	**Pressure Drop in Two-Phase Flow:** Two-Phase Frictional Pressure Drop in Homogeneous Flow, Empirical Two-Phase Frictional Pressure Drop Methods, Single–Phase Flow Pressure Drops Caused by Flow Disturbances, Pressure Change Caused by Other Flow Disturbances, Two-Phase Flow Local Pressure Drops.	6
	Total	36

Text Books:

1. S. M., Ghiaasiaan,: Two-Phase flow,Boiling, and Condensation, Cambridge University Press, 2007.

Reference Books:

1. K. Wark, Advanced Thermodynamics for Engineers, McGraw Hill, 1997.
2. C.E. Brennen, Fundamentals of Multiphase Flow, Cambridge University Press, 2005.

3. J. G. Collier, and J. R Thome.: Convective Boiling and Condensation, 3rd ed., Oxford University Press, 1994.
4. G.B Wallis: One-Dimensional Two-Phase Flow, McGraw Hill Higher Education, 1983.

Program:	M. Tech. Mechanical (Heat Power Engineering)				Semester: II	
Course :	Professional Elective Lab. II (ELIII & ELIV)				Code : MMH2506	
Teaching Scheme			Evaluation Scheme			
Practical	Hours	Credit	TW	PR	OR	Total
2	2	1	50	--	50	50

Guidelines :

1. **Any one subject from Part A and Part B** as per students elective choices
2. Total experiments to be conducted are Three **from Part A and Three from Part B**
3. **Total : 6 experiments 12 hours**

Detailed Syllabus:

Part A: Elective 1- Building Energy System & Technology (ANY Three)

Expt.	Description	Duration, h
1.	Case study of Energy use in Commercial Buildings- Benchmarking of energy performance using various tools	6
2.	Case study / Visit to Net Zero Energy Consumption building	
3.	Building Energy Simulation using E-Quest for design optimization and evaluation of energy saving measures	
4.	Developing energy models for a building as per ECBC 2017 / ASHRAE 90.1 requirements	
	Total	06

Part A: Elective 1- Thermal and Electrical Energy Storage (ANY Three)

Expt.	Description	Duration, h
1.	Determine the Wh and Ah efficiency of a lead acid battery	6
2.	Determine the Wh and Ah efficiency of a Lithium- Ion batterY	
3.	To determine capacity of a given battery and obtain its discharge characteristics	
4.	Determination of SOC of a battery (specific gravity method, 2 min discharge test method)	
5	Maintenance of battery using equalizing charge	
6	Assignment on sizing of Battery for a specific application	
	Total	06

Part A: Elective 1- Combustion in IC Engines & Emission Control (ANY Three)

Expt.	Description	Duration, h
1.	Analysis of effect of load on emissions of single cylinder diesel engine	6
2.	Analysis of effect of speed on emissions of multi-cylinder petrol engine	
3.	Analysis of effect of compression ratio on emissions of single cylinder diesel engine	
4.	Analysis of effect of A:F ratio on emissions of single cylinder diesel engine	
	Total	06

Part B: Elective 2- Design of Thermal System(ANY Three)

Expt.	Description	Duration, h
1.	Assignment on modeling and information flow diagram	6
2.	Case-study on system simulation	
3.	Assignment on Optimization using search methods	
4.	Design of piping systems	
5.	Design of process equipment/system	
6.	Design of pumps/fans/compressor	
	Total	06

Part B: Elective 2- Two Phase Flow (ANY Three)		
Expt.	**Description**	**Duration, h**
1.	Determination of mass fraction/mole fraction of components in single phase multicomponent mixture	**6**
2	Assignment based on two phase flow regimes	
3.	Assignment based on two phase flow regime I	
4.	Determination of pressure drop-in two-phase flow	
	Total	**06**
Part B: Elective 2- Turbulent Flow (ANY Three)		
Expt.	**Description**	**Duration, h**
1	Flow over a circular cylinder – for various Reynolds number	**6**
2	Flow over flat plate or circular cylinder or an airfoil a. Study flow separation b. Effect of boundary layer c. Incorporate the effect of convection (in flat plate case study)	
3	Modelling of water flow through the sudden contraction and expansion in horizontal pipe. Grid independence study and effect of y+ using suitable case study	
	Total	**06**

Program:	M.Tech Mechanical (Heat Power Engineering)			Semester :	II	
Course :	Integrated Mini-Project			Code :	MMH2701	
Teaching Scheme			Evaluation Scheme			
Practical	Hours	Credit	TW	PR	OR	Total
6	6	3	50	--	50	100

Pre-requisite:

1. Basics of Fluid mechanics, Heat Transfer and thermodynamics
2. Basics of MATLAB and ANSYS

Objectives:

1. To understand the ―Product Development Process‟ including budgeting through Mini Project.
2. To plan for various activities of the project and channelize the work.
3. To build, design and implement real time application using available platforms

Outcomes:

After learning the course the students should be able to:

1. Understand, plan and execute a Mini Project.
2. Design real time application
3. Prepare a technical report based on the Mini project.
4. Deliver technical seminar based on the Mini Project work carried out.
5. Understand publication and copyright process of research

Guidelines: Total: 24 h (contact) + 48 h(non-contact/implementation)

4. Individual student needs to design and demonstrate Mini-project under the guidance of allocated guide.
5. Students can choose the project considering their future implementation in Major Project in second year
6. The hardware implementation and software simulation is compulsory.
7. Mini-Project Report should be submitted as a compliance of term work associated with subject.
8. Paper publication associated with mini-project as research outcome is appreciable.
9. Mini-project work preferably should be completed in laboratory.

Detailed Syllabus:

Integrated Mini-Project

Sr. No.	Activity	Duration
1.	Week 1 &2 : Mini-project guide allotment, finalization of topic and platform, Planning of the work	4
2.	Week 3&4: Literature review and specification and Methodology Finalization, Review 1 for finalization of topic and specification.	4
3.	Week 5&6 : Simulation of Idea on appropriate software tools and finalization of hardware platform	4
4.	Week 7 & 8 : understanding platform implementation and related software flow and execute block level design , Review 2 to understand the progress of the project	4
5.	Week 9 & 10: Mini Project Report writing and publication or copyright planning and execution.	4
6.	Week 11&12: Demonstration of Project work and Final Review for submission and term work compliances.	4
	Total	24

Program:	M.Tech Mechanical (Heat Power Engineering)			Semester : II		
Course :	Skill Development Lab - II (Soft Skills and English Aptitude)			Code: M_2101		
Teaching Scheme			Evaluation Scheme			
Practical	Hours	Credit	TW	PR	OR	Total
2	2	2	50	--	50	100

Pre-requisite: -

Objectives:

1. To facilitate holistic growth
2. To make the students aware about the significance of Soft Skills and English Aptitude
3. To develop the ability of effective communication through individual and group activities
4. To expose students to right attitude and behavioural aspects and build the same through various activities

Outcomes:

After learning the course the students should be able to:

1. Express effectively through verbal/oral communication skills
2. Prepare for group discussions/meetings/interviews and presentations
3. Operate effectively in multi-disciplinary and heterogeneous teams through the knowledge of team work, inter personal relationships, conflict management and leadership activities

Guidelines :

1. Total experiments to be conducted are Six **out of eight**
2. **Total : 6 experiments 12 hours**

Detailed Syllabus:

Skill Development Lab (ANY Six)

Expt.	Description	Duration h
1.	**Group Discussion:** Make students aware of proper and globally accepted ethical way to handle work, colleagues and clients. Develop group communication skills. Learn to speak up one's opinion in a forum. Cultivate the habit of presenting solution-driven analytical arguments making them contributors in any team.	2
2.	**Public Speaking:** Any one of the following activities may be conducted: **1. Prepared speech** (Topics are given in advance, students get 10 minutes to prepare the speech and 5 minutes to deliver.) **2. Extempore speech** (Students deliver speeches spontaneously for 5 minutes each on a given topic)	2
3.	**Writing An Article On Any Social Issue:** Build writing skills, improve language and gain knowledge about how to write an article/ report	2
4.	**Reading and Listening skills:** The batch can be divided into pairs. Each pair will be given a article by the facilitator. Each pair would come on the stage and read aloud the article one by one. After reading by each pair, the other students would be asked questions and needful corrections in the article. The facilitator can evaluate the students for reading and listening skills.	2
5.	**Debate On Current Affairs/ Social Relevance Topics:** Cultivate the habit to present forceful arguments while respecting the opponents perspective and enhance verbal skills.	2
6.	**Telephonic etiquettes:** To teach students the skills to communicate effectively over the phone. Students will be divided into pairs. Each pair will be given different situations, such as phone call to enquire about job vacancy, scheduling a meeting with team members, phone call for requesting of urgent leave from higher authorities. Students will be given 10 min to prepare. Assessment will be done on the basis of performance during the	2

	telephone call.	
7.	**Email etiquettes:** To provide students with an in-depth understanding of writing formal emails.	**2**
8.	**Mock interviews:** Guide students and conduct mock interviews	**2**
	Total	**12**

Text Books:

1. B. Mitra, Personality Development and Soft Skills
2. S. Lucas,The Art of Public Speaking

Reference Books:

1. M. Weaver, Empowering Employees Through Basic Skills
2. G. Ratigan, Aced: Superior Interview Skills to Gain an Unfair Advantage to Land Your DREAM JOB!

Course Syllabus

Semester-III

Program:	M. Tech. Mechanical (Heat Power Engineering)				Semester :	III
Course :	Seminar				Code :	MMH3703
Teaching Scheme			Evaluation Scheme			
Practical	Hours	Credit	PR	TW	OR	Total
4	4	2	--	50	50	100

Guidelines :

1. Individual student need to study recent topics in the field of Heat Power Engineering under the guidance of allocated guide.
2. Students can choose topic considering recent trends and its societal importance.
3. The extensive Literature Survey, Mathematical Modelling of particular method and valuable conclusion is expected from seminar study.
4. Seminar Report should be submitted as a compliance of term work associated with subject.
5. At least 1 review paper publication is expected as research outcome of seminar.
6. Total Duration : 24 Contact Hours and 24 Hours should be spend by students on completion of related activities and requirements.

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Detailed Syllabus:

Seminar Activities

Sr. No.	Activity	Duration h
1.	Week 1 &3 : Guide allotment, finalization of topic, Planning of the work. Review-1 conduction	6
2.	Week 4&5: Literature review, Specification and Methodology Finalization, of detail topic.	4
3.	Week 6& 8 : Detail Topic Mathematical model, methodology and findings Review-2 conduction	6
4.	Week 9&10 : Comparison of detail topic with other existing methods	4
5.	Week 11 & 12: Seminar Report writing and publication or copyright planning Final Review conduction.	4
	Total	24

Program:	M. Tech. Mechanical (Heat Power Engineering)			Semester :	III	
Course :	Internship [Company/Inhouse project]			Code :	MMH3801	
Teaching Scheme			Evaluation Scheme			
Practical	Hours	Credit	IE 1	TW	OR	Total
4	4	2	50	--	50	100

Guidelines :

1. Individual student need to attempt for internship with help of PCCOE T&P cell in the field of Heat Power Engineering under the guidance of allocated guide.
2. If not get selected for any internships, students can choose extension of mini-project / opportunity of Entrepreneurship opportunity from PCCOE topic considering recent trends and its societal importance.
3. The idea presentation is expected from the students based on their topics .
4. Internship Report should be submitted as a compliance of term work associated with subject.
5. Total Duration : 24 Contact Hours and 24 Hours should be spend by students on completion of related activities and requirements.

Detailed Syllabus:

Internship/ Inhouse/ Entrepreneurship activity

Sr. No.	Activity	Duration h
1.	Week 1 &3 : Guide allotment, Application of internships, finalization of topic, Planning of the work. Review-1 conduction	6
2.	Week 4&5: Internship/ Mini-project/ Entrepreneurship activity implementation as per requirements	4
3.	Week 6& 8 : Review-2 of Activities	6
4.	Week 9&10 : Interaction of Guides with Industry, Poster Presentation	4
5.	Week 11 & 12: Internship Report writing and publication or copyright planning Final Review conduction.	4
	Total	30

Program:	**M. Tech. Mechanical (Heat Power Engineering)**				**Semester : III**	
Course :	MOOCs/ Entrepreneurship				**Code : MMH3981**	
Teaching Scheme			**Evaluation Scheme**			
Practical	**Hours**	**Credit**	**IE1**	**TW**	**OR**	**Total**
4	4	2	50	--	50	100

Guidelines :

1. Individual student needs to register for MOOC course of their interest or Entrepreneurship related trainings.
2. Week assignment needs to be regularly completed as per requirement of course, which will be considered for internal assessment of course.
3. The certification of course or training is mandatory.
4. Oral and Presentation of course/ training will be taken at the end of semester
5. Total Duration: 24 Contact Hours and 24 Hours should be spent by students on completion of related activities and requirements.

Program:	M. Tech. Mechanical (Heat Power Engineering)			Semester :	III
Course :	Dissertation Phase – I [Company/ In-house project]			Code :	MMH3702
Teaching Scheme			Evaluation Scheme		
Practical	Hours	Credit	IE 1	PR	OR	Total
20	20	10	100	--	100	200

Pre-requisite:

1. Mechanical system design

Objectives:

1. To understand the product development process including budgeting.
2. To plan for various activities of the major project and channelize the work towards product development.
3. To build, design and implement real time application.
4. To inculcate research culture in students for their technical growth.

Outcomes:

After learning the course the students should be able to:

1. Understand, plan and execute the major Project with appreciable research outcomes.
2. Design real time application considering immerging areas in technology
3. Prepare good quality technical report based on the project.
4. Demonstrate technical ideas and its relevance in recent technology
5. Publish good quality paper in reputed journal and present their work in reputed conferences.

Guidelines :

1. Individual student need to design and demonstrate project under the guidance of allocated guide.
2. Sponsored Project or Project Internship is acceptable considering postgraduate scope.
3. The physical / soft model and validation of results is compulsory.
4. Project Report-1 should be submitted as a compliance of term work associated with subject.
5. At least 2 paper publications are expected as research outcome of Project Stage-I (Conference or reputed journal) and 40% of planned project work should be completed for submission of Dissertation Phase-I
6. Total Duration: 120 hours are contact hours with guides and for reviews, 120 hours are expected to be spend by students to satisfy all project requirements and implementations.

Detailed Syllabus:

Integrated Mini-Project

Sr. No.	Activity	Duration, h
1.	Week 1, 2 and 3: Guide allotment, applying for sponsorship and project internship, finalization of topic and platform, Planning of the work.	30
2.	Week 4 & 5: Literature review, objectives and methodology Finalization, Review 1 for finalization of topic and objectives.	20
3.	Week 6, 7 & 8: understanding, analytical / numerical calculations and design of components, Review 2 to understand the progress of the project	30
4.	Week 9 & 10: preparation of the experimentation plan and measurement system for experimentation	20
5.	Week 11 & 12: Project Report writing and publication or copyright planning and execution. Demonstration of Project work and Final Review for submission and term work compliances	20
	Total	120

Course Syllabus

Semester-IV

Dissertation Phase – II (Company/ In-house project)						
Program: M.Tech (Heat Power Engineering)				**Semester :** IV		
Course : Dissertation Phase – II [Company/ In-house project]				**Code :** MMH4704		
Teaching Scheme			**Evaluation Scheme**			
Practical	**Hours**	**Credit**	**IE 1**	**PR**	**OR**	**Total**
24	**24**	**12**	**200**	**--**	**200**	**400**

Pre-requisite: Basics of Heat Transfer, Fluid mechanics, thermal engineering**,** Basics of ANSYS, MATLAB programming

Objectives:

1. To understand the Product Development Process including budgeting.
2. To plan for various activities of the major project and channelize the work towards product development.
3. To build, design and implement real time application using available platforms.
4. To inculcate research culture in students for their technical growth.

Outcomes:

After learning the course the students should be able to:

1. Understand, plan and execute the major Project with appreciable research outcomes.
2. Design real time application considering immerging areas in technology
3. Prepare good quality technical report based on the project.
4. Demonstrate technical ideas and its relevance in recent technology
5. Publish good quality paper in reputed journal and present their work in reputed conferences.

Guidelines :

1. Semester III major project is to be completed in this section under the guidance of same project guides.
2. Students need to implement the project using suitable hardware and software platforms
3. Final Project Report including all process of project should be submitted as a compliance of term work associated with subject and permission to appear for examination.
4. Total 3 Paper publications are expected as research outcome of Project Stage-I and II (Conference or reputed journal) and 100% of planned project work should be completed for submission of Dissertation Phase-I
5. Total Duration: 144 hours are contact hours with guides and for reviews , 144 hours are expected to be spend by students to satisfy all project requirements and implementations.

Detailed Syllabus:

Integrated Mini-Project

Sr. No.	Activity	Duration h
1.	Week 1 &2 : 60 % Work should be completed.	24
2.	Week 3&4: Software Simulation and Hardware Implementation should be completed. Review 1 conduction.	24
3.	Week 5& 6 : Paper Publication should be in process or completed during this week, 80% work should be completed.	24
4.	Week 7&8 : Compliance of 100 % work. Review -2 will be conducted	24
5.	Week 9 & 10: Department Reviews will be conducted to check the quality of project and requirements fulfillment to permit project submission.	24
6.	Week 11 & 12: Project Report writing and copyright planning and execution. Demonstration of Project work and Final Research Review Committee (RRC) reviews will be conducted for submission and term work compliances	24
	Total	**144**

MOOCS/ ENTREPRENEURSHIP						
Program:	**M.Tech (Heat Power Engineering)**				**Semester :**	**IV**
Course :	MOOCs/ Entrepreneurship				**Code :**	**MMH4982**
Teaching Scheme			**Evaluation Scheme**			
Practical	**Hours**	**Credit**	**IE1**	**TW**	**OR**	**Total**
4	4	2	50	--	50	100

Guidelines :

1. Individual student needs to register for MOOC course of their interest or Entrepreneurship related training.
2. Week assignment needs to be regularly completed as per requirement of course, which will be considered for internal assessment of course.
3. The certification of course or training is mandatory.
4. Oral and Presentation of course/ training will be taken at the end of semester
5. Total Duration: 24 Contact Hours and 24 Hours should be spent by students on completion of related activities and requirements.

Annexure -1

Open Elective Syllabus

Program:	M. Tech. Mechanical (Design Engineering)				Semester : I	
Course :	Advanced Materials				Code: MMD1601A	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Pre-requisite:

Chemistry, Physics, Material Science, Metallurgy

Objectives:

1. To introduce advanced and exotic materials.
2. To familiarize students with structure and properties of materials.
3. To establish significance of material selection in engineering design.
4. To explore new design opportunities.

Outcomes:

After learning the course, the students should be able to:

1. Student will be able to analyze of different materials in advanced engineering application.
2. Student will be able to relate structure and properties of new materials in engineering applications
3. Student will be able to evaluate and select materials for advanced engineering applications.

Detailed Syllabus:

Unit	Description	Duration, h
1	Advanced and exotic materials – ceramics and Plastics, Biomaterials, Aerogels, Superconductors, Carbon nano tubes	8
2	Mechanical, electrical, optical and magnetic properties of materials.	8
3	Smart materials, Piezoelectricity, Magnetostriction, smart polymers, Shape memory alloys	6
4	Introduction to nano, Nano-biomimicry, Synthesis of nanomaterials by physical and chemical methods, Synthesis of nanomaterials by biological methods, Characterizations of nanomaterials.	6
	Total	24

Text Books:

1. W.D. Callister Material Science and Engineering: An Introduction, Wiley publication.

Reference Books:

1. Malsch, N.H., “Biomedical Nanotechnology”, CRC Press. (2005).
2. L.F. Pease, R.M. Rose and J. Wulff, Electronic Properties (Volume IV: Structure and Properties of Materials)

Program:	M. Tech. Mechanical (Design Engineering)				Semester : I	
Course :	Optimization Methods				Code: MMD1601B	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Pre-requisite: Engineering Mathematics

Objectives:

1. To introduce students to the modeling of constrained decision-making problems and optimization.
2. Provide students with the basic mathematical concepts of optimization.
3. Provide students with the modelling skills necessary to describe and formulate optimization problems.
4. Provide students with the skills necessary to solve and interpret optimization problems in engineering.

Outcomes:

After learning the course, the students should be able to:

1. Formulate mathematical programs in various practical systems
2. Understand basic optimization techniques
3. interpret the results of a model and present the insights (sensitivity, duality)
4. Know the limitations of different solution methodology
5. Use software to solve problems

Detailed Syllabus:

Unit	Description	Duration, h
1.	**Classical Optimization Techniques** Introduction to Mathematical Modeling, Single variable optimization and multi variable optimization, with constraints and without constraints	6
2.	**Linear and non-Linear Programming** Simplex Methods, Elimination and iterative methods for one-dimensional minimization .	6
3.	**Simulation Modeling** Introduction, definition and types, limitations, various phases of modeling, Monte Carlo method, applications, advantages and limitations of simulation	6
4.	**Modern Methods of Optimization** Genetic algorithms, Simulated Annealing, Particle Swarm Optimization, Ant Colony Optimization, etc.	6
	Total	24

Text Books:

1. Engineering Optimization: Theory and Practice, Singiresu S. Rao, John Wiley & Sons
2. Practical Optimization Methods with Mathematical Applications, M. Asghar Bhatti, Springer
3. Optimization for engineering design, K. Deb, PHI

Reference Books:

1. Topology Optimization – Theory, Methods and Applications, M. P. Bendse, Q. Sigmund
2. Evolutionary Topology Optimization of Continuum Structures, Methods and Applications, X. Huang, Y.M. Xie, Wiley
3. Structural Optimization, Raphael T. Haftka and Zafer Gurdal, Kluwer Academic Publishers
4. Mathematical Modelling, J N Kapur, New age international publication
5. Optimization concepts and applications in engineering, Belegundu, Chandrupatla, Pearson Education

Program:	**M. Tech. Mechanical (Design Engineering)**				**Semester : I**	
Course :	**Modeling and Simulation of Dynamic systems**				**Code: MMD1601C**	
Teaching Scheme			**Evaluation Scheme**			
Lecture	**Hours**	**Credit**	**IE 1**	**IE 2**	**ETE**	**Total**
2	**2**	**2**	**20**	**--**	**30**	**50**

Pre-requisite: Engineering Mathematics

Objectives:

1. Students able to model any physical system for realtime applications
2. Students able to simulate any physical system for realtime applications

Outcomes:

After learning the course, the students should be able to:

1. Develop mathematical model for practical problem
2. Develop Bond Graph model for system
3. Apply transfer function and State space model techniques
4. Simulate the system using suitable software and Estimate parameters by optimization

Detailed Syllabus:

Unit	**Description**	**Duration h**
1.	Introduction to Modelling and Simulation, Basic systems, Introduction and Types of Mathematical modelling, Basic building blocks Mechanical, Electrical, Thermal systems.	**6**
2.	Bond Graph Modelling of Dynamic Systems: Representation,Elements, Single,Two and multiports Causality, Application to basic Mechanical,Electrical and Electromechanical system	**6**
3.	Dynamic Response and System Transfer Function: Poles, Stability Block diagram/Signal flow diagram/State Space formulation and Frequency response	**6**
4.	Simulation and Simulation application Parameter Estimation, System Identification and Optimization	**6**
	Total	**24**

Reference Books:

1. Brown, Forbes T. Engineering System Dynamics. New York, NY: CRC, 2001. ISBN: 9780824706166.

Program:	M. Tech. Mechanical (Design Engineering)				Semester : II	
Course :	Room Acoustics				Code : MMD2602A	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Pre-requisite: Engineering Mathematics, Physics,

Objectives:

The course includes sound fields in rooms with wave theoretical methods, geometrical acoustics methods Acoustical measurement techniques, sound absorption for evaluation of room acoustic quality

Outcomes:

After learning the course, the students should be able to:

Understand Basic principals in acoustics, measurement of sound Power and apply to analyze effectiveness in compliance to noise regulations.

Detailed Syllabus:

Unit	Description	Duration h
1.	**Basics of acoustics –** Terminologies speed of sound, wavelength, frequency, and wave number, acoustic pressure, acoustic intensity and acoustic energy density, spherical wave, **Acoustic measurement** Directivity factor and directivity index, levels and the decibel, combination of sound sources, octave bands, weighted sound levels. Sound power measurement	6.
2.	**Transmission of Sound:** changes in media with normal incidence, changes in media with oblique incidence, sound transmission through a wall, transmission loss for walls - stiffness-controlled region- mass-controlled region - damping-controlled region,	6
3.	**Sound Absorption:** General description of acoustical materials - acoustical tiles, fiberboard, resonator absorption unit absorber, carpets, acoustical plaster, resilient packing composite materials, etc. Their use, selection criteria and construction.	6
4.	**Room acoustics** - surface absorption coefficients, steady-state sound level in a room, Behaviour of sound in an enclosed space. Concept of reverberation and reverberation time effect of energy absorption in the air, noise from an adjacent room, acoustic enclosures, acoustic barriers.	6
	Total	24

Text Books:

Industrial Noise Control, Randell Barron, Marcel Dekker, Inc.

Reference Books:

Mechanical Vibrations & Noise Engineering, A.G.Ambekar, Prentice Hall of India, New-Delhi.

Program:	M. Tech. Mechanical (Design Engineering)				Semester : II	
Course :	Design Thinking				Code: MMD2602B	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Pre-requisite:
Any Engineering Graduate

Objectives:
1. To acquaint with concepts of Design Thinking.
2. To apply design thinking tools in every field of Engineering.

Outcomes:
After learning the course, the students should be able to:
1. Use Design Thinking tools.
2. Create simple Products using design thinking tools

Detailed Syllabus:

Unit	Description	Duration h
1.	Introduction to Design thinking and its importance. Steps in Design Thinking	04
2.	Empathize Phase	04
3.	Define Phase	04
4.	Ideate Phase	04
5.	Prototype Phase	04
6.	Test Phase. One simple Product development using Design thinking tools	04
	Total	24

Reference Books:
1. Design Thinking methodology book by Emrah Yayici , Publisher Emrah Yayici, 2016
2. Designing for Growth: A design thinking toolkit for managers, Tim Ogilvie ,Columbia Business School Publishing

Program:	M. Tech. Mechanical (Design Engineering)				Semester : II	
Course :	Reliability Engineering				Code: MMD2602C	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE1	IE2	ETE	Total
2	2	2	20	--	30	50

Pre-requisite: Engineering Mathematics

Objectives:

1. To perform reliability engineering analysis.
2. To compute reliability engineering parameters and estimates for applications in mechanical devices and manufacturing environments.

Outcomes:

After learning the course, the students should be able to:

1. Identify the possible faults in systems and their impacts to the overall system reliability.
2. Develop fault trees for a sub-system and apply various reliability models on fault analysis.
3. Evaluate maintenance schedules and assess the corresponding risk with appropriate techniques and tools.

Detailed Syllabus:

Unit	Description	Duration h
1.	**Fundamental concepts - I** Failure density, failure rate, hazard rate, MTTF, MTBF, pdf, cdf, modes of failure, Areas of reliability, Quality and reliability assurance rules, product liability, probability distributions binomial, normal, Poisson.	6
2.	Sy**stem reliability** Series, parallel, mixed configuration, k- out of n structure, complex systems- enumeration method, conditional probability method, cut set and tie set method,	6
3.	**Redundancy** Element redundancy, unit redundancy, standby redundancy- types of stand by redundancy, parallel components single redundancy, multiple redundancy. Markov analysis.	6
4.	**System reliability Analysis** Reliability apportionment, Reliability apportionment techniques – equal apportionment, AGREE, ARINC, feasibility of objectives apportionment.	6
	Total	**24**

Text Books:

1. L.S. Srinath, Concepts of Reliability Engg., Affiliated East-Wast Press (P) Ltd., 1985.
2. E. Balagurusmy, Reliability Engineering, Tata McGraw-Hill Publishing Co. Ltd., 1984.

Reference Books:

1. A.K. Govil, Reliability Engineering, Tata McGraw-Hill Publishing Co. Ltd., 1983.
2. B.S. Dhillion, C. Singh, Engineering Reliability, John Wiley & Sons, 1980.
3. M.L. Shooman, Probabilistic, Reliability, McGraw-Hill Book Co., 1968.
4. P.D.T. Conor, Practical Reliability Engg., John Wiley & Sons, 1985.
5. K.C. Kapur, L.R. Lamberson, Reliability in Engineering Design, John Wiley & Sons, 1977.
6. A. Birolini , Reliability Engineering, Theory and Practice, Third Edition, Springer, 1999

Program:	M. Tech (E&TC)-VLSI and Embedded Systems				Semester:	I
Course:	Automotive Electronics and its Applications				Code:	MET1601A
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Pre-requisite: Knowledge of electronics & electrical, instrumentation, control systems, and IC engine operation, etc.

Objectives:

1. To learn and understand the various application of electronics systems and ECU in automotive.
2. To learn and understand principles and applications of sensors and actuators in automotive electronics systems.
3. To learn and understand various control systems in automotive

Outcomes:

After learning the course, the students should be able to:

1. Acquire an overview of automotive components, subsystems, and basics of electronic control in today's automotive industry.
2. Use and apply available automotive sensors and actuators in various electronic control systems while designing automotive system design.
3. Apply knowledge of modern technologies in automotive design.

Detailed Syllabus:

Unit	Description	Duration h
1.	**Automotive Systems Overview:** Automotive vehicle technology, Present trends in automobiles with emphasis on increasing role of electronics and software, Overview of typical automotive subsystems and components, Body, Chassis, and Powertrain Electronics	6
2.	**Sensors and Actuators:** Basic sensor arrangement, Types of sensors such as oxygen sensors, Crank angle position sensors, Fuel metering/ vehicle speed sensors, Flow sensor, Temperature, EGO, Air mass flow sensors, Throttle position sensor, Solenoids, Stepper Motors, Relays, etc.,	6
3.	**Engine Control System:** Algorithms for engine control including open loop and closed loop control system, Electronic ignition, EGR for exhaust emission control. Look-up tables and maps, Need of maps, Procedure to generate maps, Engine calibration, Torque table, Dynamometer testing	6
4.	**Active and passive safety systems:** Body electronics including lighting control, Remote keyless entry, Immobilizers etc., Electronic instrument clusters and dashboard electronics, Antilock braking system, Electronic stability program, Air bags, Computer vision based ADAS	6
	Total	24

Text Books:

1. William B. Ribbens, "Understanding Automotive Electronics- An Engineering Perspective", Seventh edition, Butterworth-Heinemann Publications.
2. Ronald K. Jurgen, "Automotive Electronics Handbook", Mc-Graw Hill.

Reference Books:

1. Robert Bosch," Automotive Hand Book", Fifth edition, SAE Publications
2. Kiencke, Uwe, Nielsen & Lars, "Automotive Control Systems for Engine, Driveline and Vehicle", Second edition, Springer Publication.
3. Automotive Electronics by Tom H. Denton
4. Automotive Electrical and Electronic Systems by John F. Kershaw, James D. Halderman / Pearson Education

Program:	M.Tech (E&TC)-VLSI and Embedded Systems			Semester:	I	
Course:	Industrial Drives			Code:	MET1601B	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Pre-requisite:
Electrical Drives, Dynamics of Electrical drives, Control Systems

Objectives:

1. To define electric drive, its parts, advantages and explain choice of electric drive.
2. To explain dynamics and modes of operation of electric drives.
3. To explain selection of motor power ratings and control of dc motor using rectifiers.
4. To analyze the performance of induction motor drives under different conditions.
5. To explain the control of induction motor, synchronous motor and stepper motor drives.
6. To discuss typical applications electrical drives in the industry

Outcomes:
After learning the course, the students should be able to:

1. Explain the advantages and choice of electric drive.
2. Explain dynamics and different modes of operation of electric drives.
3. Suggest a motor for a drive and control of dc motor using controlled rectifiers.
4. Analyze the performance of induction motor drives under different conditions.
5. Control induction motor, synchronous motor and stepper motor drives.
6. Suggest a suitable electrical drive for specific application in the industry

Detailed Syllabus:

Unit	Description	Duration h
1.	**Selection of Motor Power Ratings:** Thermal Model of Motor for Heating and Cooling, Classes of Motor Duty, Determination of Motor Rating. **Direct Current Motor Drives:** Controlled Rectifier Fed dc Drives, Single Phase Fully Controlled Rectifier Control of dc Separately Excited Motor, Single Phase Half Controlled Rectifier Control of dc Separately Excited Motor, Three Phase Fully Controlled Rectifier Control of dc Separately Excited Motor, Three Phase Half Controlled Rectifier Control of dc Separately Excited Motor, Multi quadrant Operation of dc Separately Excited Motor Fed Form Fully Controlled Rectifier, Rectifier Control of dc Series Motor, Supply Harmonics, Power Factor and Ripple in Motor Current, Chopper Control of Separately Excited dc Motor, Chopper Control of Series Motor.	6
2.	**Induction Motor Drives:** Analysis and Performance of Three Phase Induction Motors, Operation with Unbalanced Source Voltage and Single Phasing, Operation with Unbalanced Rotor Impedances, Analysis of Induction Motor Fed from Non-Sinusoidal Voltage Supply, Starting, Braking, Transient Analysis. Speed Control Techniques-Stator Voltage Control, Variable Voltage Frequency Control from Voltage Sources.	6
3.	Voltage Source Inverter (VSI) Control, Cyclo-converter Control, Closed Loop Speed Control and Converter Rating for VSI and Cyclo-converter Induction Motor Drives, Variable Frequency Control from a Current Source, Current Source (CSI) Control, current regulated voltage source inverter control, speed control of single phase induction motors.	6
4.	**Synchronous Motor Drives:** Operation from fixed frequency supply-starting, synchronous motor. Self-controlled synchronous motor drive employing load commutated thruster inverter, Starting Large Synchronous Machines, Permanent Magnet ac (PMAC) Motor Drives, Sinusoidal PMAC Motor Drives, Brushless dc Motor Drives. **Stepper Motor Drives:** Variable Reluctance, Permanent Magnet, Important Features of Stepper Motors, Torque Versus Stepping Rate Characteristics, Drive Circuits for Stepper Motor. **Industrial Drives:** Textile Mills, Steel Rolling Mills, Cranes and Hoists, Machine Tools.	6
	Total	**24**

Text Books:

1. Gopal K Dubey , Fundamentals of the electrical drives Narosa publication
2. N. Mohan T.M. udeland & W.P.Robbins , Power Electronics converter application J.Wiley & sons
3. Vedam Suryavanshi**,** Electrical Drives Concept and application
4. B.K. Bose, Advanced power Electronics & A.C. Drives

5. S.K.Pillar, Analysis of thyristor power conditioned motors

Reference Books:

1. N.K De,P.K. Sen , Electric Drives PHI Learning 1 st Edition, 2009
2. Gobal K.Dubey, Fundamentals of Electrical Drives- Alpha Science Int. Ltd.,
3. Shepherd Hullay & Liag, Power Electronics & Motor Control -, Cambridge Univ. Press
4. Gopal K Dubey, Power Semiconductor controlled Drives, - Prentice Hall pub.
5. R. Krishnan, Electric Motor Drives–Modelling, Analysis and Control, - Pearson Education, 2003
6. P.C. Sen , Thyristorised DC Drives -, Krieger pub.
7. S.B.Dewan, G.R.Slemon & A.Stranghan; Power Semi conductor controlled Drives - John-Willey pub.

Program:	M.Tech (E&TC)-VLSI and Embedded Systems				Semester : I	
Course :	Basic of FPGA and CPLD				Code : MET1601C	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE1	IE2	ETE	Total
2	2	2	20	--	30	50

Pre-requisite: Fundamentals of digital electronics, Knowledge of one hardware description language

Objectives:

1. To make students familiar with programmable logic devices and its architectures.
2. To understand the architecture and features of FPGA and CPLD .
3. To make the students familiar with the design process and how the design is mapped to the existing hardware in FPGA and CPLD.

Outcomes:

After learning the course the students should be able to:

1. To understand the depth of CPLD and FPGA architectures.
2. To design a system using FPGAs.
3. To demonstrate an understanding of interfacing of different external devices with FPGA/CPLD.
4. To apply the complete design flow of FPGA and CPLD for the specific application.

Detailed Syllabus:

Unit	Description	Duration h
2.	**Introduction:** Introduction to Hardware Description language, Need of Programmable logic devices, PLA PAL, CPLD, FPGA: General Architecture, features CPLD Architecture: overview, specification and applications, Features of XC9500 series of CPLD family.	6
2.	**FPGA Architecture:** Xilinx Logic Cell Array, Configurable Logic Block, I/O Block, Programmable Interconnects, Programming methods, Advanced features of Xilinx 4000 series Technology Trends: Device capacity, Utilization and Gate Density, Programming methods, General Design Flow, General Design Guidelines.	6
3.	**Interfacing with FPGA/CPLD:** The purpose of interfacing, interfacing of external devices such as WiFi Module, Bluetooth Module, GPS Module, Zigbee Module, Different types of display devices with FPGA/CPLD	6
4.	**Case Studies-FPGA/CPLD:** Xilinx Virtex-6, Spartan-6, Z-board Advanced features in FPGA based on Case studies. **Logical Design by FPGA/CPLD:** Complete design of any combinational circuit by gates, Boolean Algebra, Design of sequential circuits	6
	Total	24

Text Books:

1. P.K.Chan& S. Mourad, Digital Design Using Field Programmable Gate Array, Prentice Hall (Pte), 1994
2. Ronald Sass and Andrew G. Schmidt, "Embedded systems design with platform FPGAs: Principles and practices", Morgan Kaufmann, 2010.
3. Design manuals of Altera, Xilinx and Actel.

Reference Books:

1. S. Trimberger, Edr. Field Programmable Gate Array Technology, Kluwer Academic Publications, 1994.
2. Ronald J Tocci, Neal S. Widmer, Gregory L. Moss, "Digital Systems: Principles & Applications", 10th Edition, Pearson, 2009
3. J. Old Field, R. Dorf, Field Programmable Gate Arrays, John Wiley & Sons, Newyork, Reprint 2008.
4. S. Brown, R. Francis, J. Rose, Z. Vransic, Field Programmable Gate Array, BSP, 2007.
5. S. Brown and J. Rose, "Architecture of FPGAs and CPLDs: A Tutorial", IEEE Design & Test of Computers, Vol. 13, No. 2, pp. 42-57, 1996.
6. S. Brown Zvonko Vranesic – Fundamentals of Digital Logic with VHDL design, McGraw Hill – 2000

Program: M.Tech (E&TC)-VLSI and Embedded Systems				Semester : I		
Course : Robotics				Code : MET1601D		
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE1	IE2	ETE	Total
2	2	2	20	--	30	50

Prior Knowledge of
1. Sensors and actuators
2. Programming language 'C', MATLAB

is essential.

Objectives:

To impart knowledge on
1. Electromechanical elements of robots
2. Control system for robot automation
3. Existing robots designed for various applications

Outcomes:

After learning the course the students should be able to:
1. Understand kinematics, statistics and dynamic of robots
2. Apply concepts of industrial automation and communication for selection of robots
3. Select sensing and actuating elements for designing robots as per applications requirements
4. Integrate and design control system and information system for various applications.

Detailed Syllabus:

Unit	Description	Duration h
1.	**Introduction to robotics:** Evolution of Robotics, Elements of robots; Kinematics of serial and parallel robots; Velocity and static analysis of robots; Dynamics of robots; Motion planning and control; Flexible manipulators; Wheeled mobile robots, classification of Robots	5
2.	**Advanced concepts in robotics:** Introduction to Cloud and Fog robotics; Basic concepts of industrial automation and communication protocols for PLC, DCS, SCADA systems; Introduction to Internet of Things, Protocols and real time applications.	5
3.	Sensing Elements **for robots:** Classification of Sensors, Encoders and Dead Reckoning Infrared Sensors, Ground-based RF Systems, Active Beacons, Ultrasonic Transponder Trilateration, Accelerometers, Gyroscopes, Laser Range Finder, Vision-based Sensors, Color-tracking Sensors, safety and motion sensors, Force/ Torque Sensors , Tactile Sensors, DC Motors, Controlling a DC Motor, Pulse Width Modulation, Stepper Motors, Servo Motor.	7
4.	Control System of Robots: Automatic-Feedback Control System, Control Elements, Control System Design, A Robot's System Dynamics, Sensory Feedback, Control Algorithms and Performances, Space Control, Introduction to Information System of Robots.	7
	Total	24

Text Books:
1. John J C, Introduction to Robotics: Mechanics and Control , Addison-Wesley (1989).
2. Appin Knowledge Solutions, Robotics (2007)
3. Ming Xie, Fundamentals of Robotics - Linking Perception to Action (2003)

Reference Books:
1. Thomas Bräunl, Embedded Robotics - Thomas Braunl (2006)
2. Bruno S and Sciavicco L, Robotics: Modelling, Planning and Control, Springer (2009).
3. Fu K S, Ralph G and Lee C S G, Robotics: Control Sensing. Vision, and Intelligence , Tata McGraw-Hill (1987).
4. Mukhopadhyay S, Sen S and Deb A K, Industrial Instrumentation, Control and Automation, Jaico (1999).
5. Rajkumar B and Dastjerdi A V, Internet of Things: Principles and Paradigms , Morgan Kaufmann (2016).

Program:	M.Tech (E&TC)-VLSI and Embedded Systems				Semester: II	
Course:	Drone Programming for Beginners				Code: MET2602A	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Pre-requisite: Basic understanding of physics (Force, Velocity, Acceleration, etc), Understanding of sensors and actuators, Control systems, Modelling Basics –MATLB & SIMULINK, Programming in python

Objectives:

1. To understand the physics behind drones
2. To create the mathematical model of quadcopter drone from simple mathematics & Experimental data
3. To implement model into Simulink & check it against real life performance

Outcomes:

After learning the course, the students should be able to:

1. Identify & select different accessories of Drones as per applications
2. Establish the mathematical model & the Physics behind Quadcopter drone
3. Design Simulink model simulating the complete dynamics of quadcopter drone.

Detailed Syllabus:

Unit	Description	Duration h
1.	**Introduction to drones:** Unmanned Aerial Systems (UAS), Basics of drones, Introduction to Drones programming and Development Tools, Current rules and regulations governing owning and operating a UAS, concerns surrounding UAS safety, security and privacy issues	6
2.	**Drone accessories and Applications:** Sensors, Motors, Propellers, Battery, Concept of propulsion, Forces working on a Flight, Principal axes and rotation of aerial systems, Stable, unstable and neutral systems, Control drone (roll, pitch and yaw), Application of drones.	6
3.	**Drone control system development in Simulink:** Control system architecture, Quadcopter with actuator & propellers functionality block, Sensing & estimation functionality block, controller functionality block, Motor mixing algorithm (RPYT) functionality block	6
4.	**Modelling, Simulation & Flight control design:** Dynamic quadcopter system Model, flight control design, 3D visualization, testing & Tuning the model, Flight operations, Applicable software for data collection, processing, and analysis	6
	Total	24

Text books:

1. Building your own drones, a beginner's guide to drones, UAVS, and ROVs- John Baichtal
2. Quadcopter modelling and control with Matlab/Simulink implementation by Muhammad Usman
3. Model based design of a quadcopter by Ryan Gordon
4. Robotics control, sensing, vision and intelligence – K.S.Fu, R.C.Gonzalez, C.G.Lee

Reference Books:

1. Robotics and control- R.K.Mittal , I.J.Nagrath
2. Drones (The ultimate guide), Ben Rupert, CreateSpace Independent Publishing Platform
3. Matlab and Simulink for engineers, Agam Kumar Tyagi, Oxford University Press, 2012

Program:	M. Tech (E&TC)-VLSI and Embedded Systems				Semester:	II
Course :	Instrumentation and Measurements				Code:	MET2602B
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Pre-requisite: Basics of sensors and Actuators, Basic of Electronics, Analog and Digital Systems

Objectives:

To impart knowledge on the following Topics -

1. Basic functional elements of instrumentation
2. Fundamentals of electrical and electronic instruments
3. Comparison between various measurement techniques
4. Various storage and display devices
5. Various transducers and the data acquisition systems

Outcomes:

After learning the course, the students should be able to:

1. Analyse different measuring parameters of any electronics/mechatronics system
2. Design and evaluate characteristics of different types of mechatronics/ electrical/ electronic system
3. Understand different types of wave/spectrum analyzer.
4. Interface various system components and analyse its data using data acquisition system.

Detailed Syllabus:

Unit	Description	Duration h
1.	Basics of Measurements: Accuracy, Precision, resolution, reliability, repeatability, validity, Errors and their analysis, Standards of measurement. Bridge Measurement: DC bridges-wheatstone bridge, AC bridges – Kelvin, Hay, Maxwell, Schering and Wien bridges, Wagner ground Connection. Electronic Instruments for Measuring Basic Parameters: Amplified DC meter, AC Voltmeter, True- RMS responding Voltmeter, Electronic multi-meter, Digital voltmeter, Vector Voltmeter.	6
2.	Oscilloscopes: Cathode Ray Tube, Vertical and Horizontal Deflection Systems, Delay lines, Probes and Transducers, Specification of an Oscilloscope. Oscilloscope measurement Techniques, Special Oscilloscopes – Storage Oscilloscope, Sampling Oscilloscope. Signal Generators: Sine wave generator, Frequency – Synthesized Signal Generator, Sweep frequency Generator. Pulse and square wave generators. Function Generators.	6
3.	Signal Analysis: Wave Analyzer, Spectrum Analyzer. Frequency Counters: Simple Frequency Counter; Measurement errors; extending frequency range of counters Transducers: Types, Strain Gages, Displacement Transducers	6
4.	Digital Data Acquisition System: Interfacing transducers to Electronics Control and Measuring System. Instrumentation Amplifier, Isolation Amplifier. An Introduction to Computer-Controlled Test Systems.IEEE-488 GPIB Bus	6
	Total	24

Text Books:

1. Modern Electronics Instrumentation & Measurement Techniques, by Albert D.Helstrick and William D.Cooper, Pearson Education. Selected portion from Ch.1, 5-13.
2. Elements of Electronics Instrumentation and Measurement-3rd Edition by Joshph J.Carr.Pearson Education. Selected portion from Ch.1,2,4,7,8,9,13,14,18,23 and 25.

Reference Books:

1. Electronics Instruments and Instrumentation Technology – Anand, PHI
2. Doebelin, E.O., Measurement systems, McGraw Hill, Fourth edition, Singapore, 1990.

Program:	M.Tech (E&TC)-VLSI and Embedded Systems	Semester :	II
Course :	Microcontrollers and Microprocessors Applications	Code :	MET2602C

Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE1	IE2	ETE	Total
2	2	2	20	--	30	50

Pre-requisite: Digital Electronics

Objectives:

1. To understand architecture and features of typical Microcontroller.
2. To understand need of microcontrollers in real life applications.
3. To learn interfacing of real-world peripheral devices
4. To study various hardware and software tools for developing applications.
5. To learn the architecture and programmer's model of advanced processor and microcontroller
6. To acquaint the learner with application instruction set and logic to build assembly language programs.

Outcomes:

After learning the course, the students should be able to:

1. Learn importance of microcontroller and microprocessor in designing embedded application
2. To apply the programming skills to develop real-life embedded application.
3. Learn use of hardware and software tools.
4. Develop interfacing to real world devices.

Detailed Syllabus:

Unit	Description	Duration h
3.	**Introduction to single chip Microcontrollers:** Intel MCS-51 family features, 8051/8031-architecture, 8051 assembly language programming, addressing modes, Programming interrupts, timers and serial communication	6
4.	**Microcontrollers and system design:** Assembly vs High-Level language programming, System Development Environment: assembler, compiler and integrated development environment, Debugging and Simulation, system design with 8051.	6
5.	**System level interfacing design;** Advanced Microprocessor Architectures- 286, 486, Pentium; Introduction to RISC processors; ARM microcontrollers; Embedded system design methodologies, embedded controller design for communication, digital control.	6
4.	**Microcontroller & Processors Applications:** Interfacing with display devices, Sensors, actuators, and memory devices. Case Study on real time embedded system.	6
	Total	24

Text Books:

1. Barry B Brey, The intel microprocessor: architecture, programming and interfacing, Prentice hall of India, New Delhi, 2003.ISBN-0138027455, 4th Edition
2. Mohammad Ali Mazidi and Janice Gillispie Maszidi "The 8051 Microcontroller and Embedded Systems" Pearson education, 2003, ISBN- 9788131710265, 2nd Edition

Reference Books:

1. Chris H. Pappas, William H. Murray, ―80386 Microprocessor Handbooks‖, McGraw-Hill Osborne Media, ISBN-10: 0078812429, 13: 978-0078812422.
3. Walter A. Triebel, ―The 80386Dx Microprocessor: Hardware‖, Software, and Interfacing, Pearson Education, ISBN: 0137877307, 9780137877300.
4. Mohammad Rafiquzzaman, ―Microprocessors: Theory and Applications: Intel and Motorola", Prentice Hall, ISBN: -10:0966498011, 13:978:0966498011.
2. K. Bhurchandi, A. Ray, ―Advanced Microprocessors and Peripherals, McGraw Hill Education, Third Edition, ISBN: 978-1-25-900613-5

Program:	**M. Tech(VLSI & Embedded Systems)**				**Semester:**	**II**
Course:	**Electronics Implementation Platform**				**Code:**	**MET2602D**
Teaching Scheme			**Evaluation Scheme**			
Lecture	**Hours**	**Credit**	**IE1**	**IE2**	**ETE**	**Total**
2	**2**	**2**	**20**	**--**	**30**	**50**

Pre-requisite: Knowledge of C language, Python, electronic circuits.

Objectives:

1. Explain about the Arduino, Raspberry Pi, PLDs and all other associated platforms
2. Understand of the importance of micro controllers and computers in science and technology.
3. Discuss basic programming and structures required for basic operation of the platform,
4. Describe how to recognize functions, operations and syntax of Python, C and C++

Outcomes:

After learning the course, the students should be able to:

1. Apply logical thinking and problem-solving skills with Arduino platform.
2. Acquire knowledge about Raspberry pi for implementation of applications
3. Understand Digital Signal processing implantation basics
4. Understanding rapid prototyping using PLDs.

Detailed Syllabus:

Unit	**Description**	**Duration h**
1.	Arduino: A open-sourceHardware, Working, Interfacing, Coding basics and small applications and Debugging.	**6**
2.	Raspberry pi : Working, Interfacing, Coding basics and small applications and Debugging.	**6**
3.	DSP processor for Real time Video and Inage Processing. : Working, Interfacing, Coding basics and small applications and Debugging.	**6**
4.	Programmable Logic devices: FPGA: Working, Interfacing, Coding basics and small applications and Debugging.	**6**
	Total	**24**

Text Books:

1. Ryan Turner,Arduino Programming: The Ultimate Beginner's & Intermediate Guide to Learn Arduino Programming Step by Step, 2019
2. Derek Molloy Exploring Raspberry Pi: Interfacing to the Real World with Embedded Linux 1st Edition,2006
3. Avtar Singh , Digital Signal Processing Implementations : Using DSP Microprocessors (with examples from TMS320C54XX),2003
4. Roger Woods, John McAllister, Ying Yi, Gaye Lightbody, FPGA-based Implementation of Signal Processing Systems, Second Edition, 2017

Reference Books:

1. Mark TorvaldsARDUINO - ARDUINO PROGRAMMING - ARDUINO FOR BEGINNERS, Second Edition June 7, 2018
2. Eben Upton Raspberry Pi User Guide 4th Edition 2019
3. Sen M. Kuo ,Real-Time Digital Signal Processing, : Implementations, Application and Experiments with the TMS320C55X, 2001
4. Cem Unsalan, Bora Tar ,Digital System Design with FPGA: Implementation Using Verilog andx VHDL , 2017

Program:	M.Tech (Computer Engineering)				Semester :	I
Course :	Programming with Python				Code :	MCE1601A
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Pre-requisite: . Basics of Programming

Objectives:

1.To acquire knowledge in Python and R programming
2.To develop Python programs with conditionals and loops and data structures
3.Acquire skills to apply data analysis methods to a problem

Outcomes:

After learning the course the students should be able to:
1.Describe the Numbers, Math functions, Strings, List, Tuples and Dictionaries in Python
2.Interpret Object oriented programming in Python
3.Apply a solution clearly and accurately in a program using Python.

Detailed Syllabus:

Unit	Description	Duration h
1.	**Introduction to Python Programming:** Python Introduction, Installing and setting Python environment in Windows and Linux, basics of Python interpreter, Execution of python program, Editor for Python code, syntax, variable, Data types. Flow control if if else, for, while, range() function, continue, pass, break. Strings: Sequence operations, String Methods.	6
2.	**Lists:** Basic Operations, List slices,list methods,list and strings **Dictionaries:** looping and dictionaries, dictionaries & lists. **Tuples and Files :** reading and writing Functions: Definition, Call, Arguments ,Input output file handling.	6
3.	**Object Oriented Programming** features in Python: Classes, Objects, Inheritance,Errors and Exceptions: try, except and else statements, Exception Objects, Regular expressions.	6
4.	**Numpy and Matplotlib** :Array operations, Numpy Side Effects, 2D Numpy Arrays , Numpy Basic Statistics. Matplotlib: Introduction, Simple plots, Line API, Legend API, Figures, Subplots. **Pandas:** Look Ups, Selections and Indexing, Filling Methods, Series operation, Handling NaN values, Mapping, Data Frames, Reading Files, Plotting, Joins, Correlation, Histograms, Rolling calculation.	6
	Total	24

Text Books:

1. Allen B Downey, ―Think PYTHON‖, O'Rielly, ISBN: 13:978-93-5023-863-9, 4th Indian Reprint 2015
2. Peng, Roger D and Elizabeth Matsui, ―The Art of Data Science." A Guide for Anyone Who Works with Data. Skybrude Consulting 200 (2015): 162

Reference Books:

1. Zed A. Shaw,Learn Python the Hard Way

Program:	M.Tech (Computer Engineering)				Semester : I	
Course :	Software Engineering Basics				Code : MCE1601B	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Pre-requisite:- None

Objectives:

1. To learn and understand the principles of Software Engineering
2. To be acquainted with methods of capturing, specifying, visualizing and analyzing software requirements.
3. To apply Design and Testing principles to S/W project development.
4. To understand project management through life cycle of the project.
5. To understand software quality attributes.

Outcomes:

After learning the course the students should be able to:

1. Decide on a process model for a developing a software project
2. Classify software applications and Identify unique features of various domains
3. Design test cases of a software system.
4. Understand basics of IT Project management.
5. Plan, schedule and execute a project considering the risk management.
6. Apply quality attributes in software development life cycle.

Detailed Syllabus:

Unit	Description	Duration h
1.	**Introduction to Software Engineering and Software Process Models:** Software Engineering Fundamentals: Nature of Software, Software Engineering Principles, The Software Process, Software Myths. Process Models :A Generic Process Model, Prescriptive Process Models: The Waterfall, Incremental Process(RAD), Evolutionary Process, Unified Process, Concurrent. Advanced Process Models & Tools: Agile software development: Agile methods, Plan-driven and agile development.	6
2.	**Software Requirements Engineering and Analysis:** Requirements Engineering: User and system requirements, Functional and non-functional requirements, Types & Metrics, A spiral view of the requirements engineering process. Software Requirements Specification (SRS): The software requirements Specification document, The structure of SRS, Ways of writing a SRS, Requirements elicitation & Analysis: Process, Requirements validation, Requirements management.	6
3.	**Design Engineering:** Design Process & quality, Design Concepts, The design Model, Pattern-based Software Design. Architectural Design :Design Decisions, Views, Patterns, Application Architectures, Modeling Component level Design: component, Designing class based components, conducting component-level design, User Interface Design: The golden rules, Interface Design steps & Analysis, Design Evaluation	6
4.	**Project Risk Management:** Risk Analysis & Management: Reactive versus Proactive Risk Strategies, Software Risks, Risk Identification, Risk Projection, Risk Refinement, Risk Mitigation, Risks Monitoring and Management, The RMMM plan for case study project	6
	Total	24

Text Books:

1. Roger Pressman, ―Software Engineering: A Practitioner ‘s Approach‖, McGraw Hill, ISBN 0–07–337597
2. Ian Sommerville, ― Software Engineering‖, Addison and Wesley, ISBN 0-13-703515-2

Reference Books:

1. Carlo Ghezzi, ―Fundamentals of Software Engineering", Prentice Hall India, ISBN-10: 0133056996
2. Rajib Mall, ―Fundamentals of Software Engineering‖, Prentice Hall India, ISBN-13: 978- 8120348981
3. Pankaj Jalote, ―An Integrated Approach to Software Engineering‖, Springer, ISBN 13: 9788173192715.
4. S K Chang, ―Handbook of Software Engineering and Knowledge Engineering‖, World Scientific, Vol I, II, ISBN: 978-981-02-4973-1
5. Tom Halt, ―Handbook of Software Engineering‖, Clanye International, ISBN10: 1632402939
6.Christine Bresnahan, Richard Blum –Linux command line and Shell Scripting Bible -Weilly , ISBN-978-0-470-25128-7

Program:	M.Tech (Computer Engineering)				Semester : I	
Course :	Basics of Machine Learning				Code : MCE1601C	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Pre-requisite:
1.Linear Algebra, Statistics, Probability and Calculus
2. Basic Programming Skills

Objectives:

1. To master the concepts of supervised and unsupervised learning, recommendation engine, and time series modeling
2. To gain practical knowledge over principles, algorithms, and applications of Machine Learning through a hands-on approach and to validate Machine Learning models and decode various accuracy metrics. Improve the final models using another set of optimization algorithms, which include Boosting & Bagging techniques
3. To acquire thorough knowledge of the statistical and heuristic aspects of Machine Learning and To comprehend the theoretical concepts and how they relate to the practical aspects of Machine Learning.
4. 4.To implement models such as support vector machines, kernel SVM, naive Bayes, decision tree classifier, random forest classifier, logistic regression, K-means clustering

Outcomes:
After learning the course the students should be able to:

1. Understand machine learning techniques and computing environment that are suitable for the applications under consideration.
2. Solve problems associated with batch learning and online learning, and the big data characteristics such as high dimensionality, dynamically growing data and in particular scalability issues.
3. Develop scaling up machine learning techniques and associated computing techniques and technologies for various applications.
4. Implement various ways of selecting suitable model parameters for different machine learning techniques.

Detailed Syllabus:

Unit	Description	Duration h
1.	**Foundations for Machine Learning [ML]:** ML Techniques overview: Supervised; Unsupervised, Reinforcement Learning,Validation Techniques (Cross-Validations)**;**Feature Reduction/Dimensionality reduction;Principal components analysis (Eigen values, Eigen vectors, Orthogonality)	6
2.	**Clustering:** Distance measures;Different clustering methods (Distance, Density, Hierarchical); Iterative distance-based clustering; Dealing with continuous, categorical values in K-Means; Constructing a hierarchical cluster; K-Medoids, k-Mode and density-based clustering; Measures of quality of clustering	6
3.	**Classification: Naïve Bayes Classifier** Model Assumptions; Probability estimation; Required data processing; M-estimates;, Feature selection: Mutual information;Classifier **K-Nearest Neighbors:** K-Nearest Neighbor algorithm; Aspects to consider while designing K-Nearest Neighbor Support Vector Machines;SVM for classification and regression problems.	6
4.	**Association Rule mining:** The applications of Association Rule Mining: Market Basket, Recommendation Engines, etc. ; A mathematical model for association analysis; Large item sets; Association Rules; Apriori: Constructs large item sets with mini sup by iterations; Interestingness of discovered association rules; Application examples; Association analysis vs. classification ; FP-trees **Research Aspects: Application of ML in various domains**-Research Paper Publication in Quality Indexed International Journals/ Conferences;Practical Implementation of Industry Projects/Applications**;** IPR	6
	Total	24

Text Books: 1. T. Hastie, R. Tibshirani, J. Friedman. The Elements of Statistical Learning, 2e, 2008. 2. Christopher Bishop. Pattern Recognition and Machine Learning. 2e.
Reference Books: 1. Ethem Alpaydin, Introduction to Machine Learning

Program:	M.Tech (Computer Engineering)			Semester : II		
Course :	Image Processing with MATLAB			Code : MCE2602A		
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Pre-requisite: Programming Basics

Objectives:

1. Develop an overview of the field of image processing.
2. Cover the basic theory and algorithms that are widely used in digital image processing.
3. Develop hands-on experience in using computers to process images.
4. Familiarize with MATLAB Image Processing Toolbox Course

Outcomes:

After learning the course the students should be able to:

1: Understand the need for image transforms different types of image transforms and their properties.

2: Learn different techniques employed for the enhancement of images.

3: Understand the need for image compression and to learn the spatial and frequency domain techniques of image compression.

4: Learn different feature extraction techniques for image analysis and recognition.

5: Develop any image processing application.

Detailed Syllabus:

Unit	Description	Duration h
2.	**Introduction:** What is image processing?, What are the fundamental issues? , What is the role of perception? Image sampling and quantization, Basic relationship between pixels, MATLAB orientations. **Image Transformations** Discrete Fourier transform, Properties of 2D DFT, FFT, Convolution, Correlation, Discrete cosine transform, Discrete Wavelet transform.	6
2.	**Image Enhancement Techniques** Spatial Domain Techniques: Basic gray level transformations, Histogram processing, Image subtraction, Image averaging, Spatial filtering, Smoothing filters, Sharpening filters. Frequency Domain Techniques: Frequency domain filtering, Image smoothing and Image sharpening using frequency domain filters.	6
3.	**Color image processing:** Color fundamentals, Color models, Color transformation, Smoothing and Sharpening **Image Compression:** Fundamentals, Encoder-Decoder model, Types of redundancies, Lossy and Lossless compression, Huffman coding, Arithmetic coding, Golomb coding, LZW coding, Block transform coding, Run-length coding, JPEG Lossless predictive coding, Lossy predictive coding, Wavelet coding.	6
4.	**Morphological Image processing:** Basics, Erosion, Dilation, Opening, Closing, Hit-or-Miss transform, Boundary Detection, Hole filling, Connected components, Convex hull, Thinning, Thickening, Skeletons, Pruning. **Image Segmentation and Representation:** Point, Line and Edge detection, Edge linking and Boundary detection, Thresholding, Basic global tresholding, Otsu's method, Region based segmentation, Use of motion in segmentation	6
	Total	24

Text Books:

1. R. C.Gonzalez, R.E.Woods," Digital Image processing", Pearson edition, Inc3/e,2008.
2. A.K.Jain," Fundamentals of Digital Image Processing", PHI,1995

Reference Books:

1. J.C. Russ," The Image Processing Handbook", (5/e), CRC, 2006
2. R.C.Gonzalez & R.E. Woods; "Digital Image Processing with MATLAB", Prentice Hall, 2003
3.W. K. Pratt, *Digital Image Processing,* John Wiley & Sons, 2006.
4.S. Ahmed, *Image Processing,* McGraw -Hill, 1994.
5.S. J. Solari, *Digital Video and Audio Compression,* McGraw-Hill, 1997

Program: M.Tech (Computer Engineering)					**Semester :** II	
Course : Linux Essentials					**Code :** MCE2602B	
Teaching Scheme			**Evaluation Scheme**			
Lecture	**Hours**	**Credit**	**IE 1**	**IE 2**	**ETE**	**Total**
2	2	2	20	--	30	50

Pre-requisite:

Objectives:

1.To acquire knowledge of basic Linux OS, commands, and terminologies

2.To develop programs using Shell scripting

3. To acquire skills related to Linux file system

Outcomes:

After learning the course the students should be able to:

1. Use common and simple Linux commands
2. Demonstrate programming ability using Unix Shell
3. Develop collaboratively using GIT and write research-papers using LaTex
4. Apply a solution clearly and accurately in Linux environment

Detailed Syllabus:

Unit	Description	Duration h
3.	**Introduction to Linux:**Linux introduction; Understanding philosophy of Linux; Understanding Software Licensing and Linux Distributions; Architecture of Linux OS; Installation of Linux OS (direct and using virtual machine); Using common Linux programs: Linux desktop environment, working with different productivity software; Understanding and managing hardware: CPU, Disk issues, Device drivers, Display etc.;	**6**
2.	**Basic Commands and Shell Scripting:** Introduction to Linux commands, concept of shell, shell variables,getcwd() and pwd; Introduction to shell programming features: Variables declaration & scope,test, return value of a program, if-else and useful examples, for and while loop, switch case; Shell functions, pipe and redirection, wildcards, escape characters; Awk script: Environment andworkflow, syntax, variables, operators, regular expressions, arrays, control flows, loops,functions, output redirections	**6**
3.	**Linux File System and Networking:** File System - Manipulating Files: creating, deleting, copying, moving, renamingetc; Using absolute and relative path; Manipulating Directories: Creating, Deleting and Managing; Basic File and Directory commands; Understanding Linux file system; Networking - Understanding network features; Configuring a network connection; Testing a network connection;	**6**
4.	**Essential System Administration** **Users and Group Management:** Users and Group management: Creation, Updating, Deletion of user and group; Commands –shadow, useradd, usermod, userdel, groupadd, groupmod, groupdeletc; Managing ownership and permission. **Process and PackageManagement:** Understanding package management,package management commands like rpm, yum, apt; Understanding Process hierarchy and identifying running processes; Log files. **Or** **Introduction to GIT and LaTEX:** LaTEX:Basic syntax, compiling and creating documents; Document structure including sections and paragraphs; Adding Images, Table ofcontents, Source code, graphs; Adding references, and Bibliography; Installation and Hands-on of LaTEX. GIT: Creating a project using GIT locally, add, commit; Branch and Merge; Cloning a remote repo, working with a remote repo; Working on a project in a distributed fashion; Hands-on of GIT.	**6**
	Total	**24**

Text Books:

1. Christine Bresnahan, Richard Blum ―Linux Essentials, Sybex, ISBN 9781119092063

2. Sumitava Das, Unix Concepts and Applications, Tata-McGraw Hill, ISBN 0-07-063546-3

Reference Books:

1.Christine Bresnahan, Richard Blum –Linux command line and Shell Scripting Bible -Weilly , ISBN-978-0-470-25128-7

Program:	M.Tech (Computer Engineering)				Semester : II	
Course :	Design with UML				Code :	MCE2602C
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Pre-requisite:
.Basic understanding of computer programming and related programming paradigms.

Objectives:
1. To introduce the concept of Object-oriented design
2. To understand and differentiate Unified Process from other approaches
3. To design static and dynamic UML diagrams

Outcomes:
After learning the course the students should be able to:
1. Understand Basic features and elements of the object-oriented approach
2. Identify, analyze, and model structural and behavioral concepts of the system.
3. Apply the concepts of architectural design for deploying the code for software.

Detailed Syllabus:

Unit	Description	Duration h
1.	Introduction to UML: Importance of modeling, principles of modeling, object-oriented modeling, conceptual model of the UML, Architecture, Software Development Life Cycle	6
2.	Basic Structural Modeling: Classes, Relationships, common Mechanisms, and diagrams. Advanced Structural Modeling: Advanced classes, advanced relationships, Interfaces, Types and Roles, Packages. Class & Object Diagrams	6
3.	Basic and Advanced Behavioral Modeling: Interactions, Interaction diagrams. Use cases, Use case Diagrams, Activity Diagrams. Advanced Behavioral Modeling Events and signals, state machines, processes and Threads, time and space, state chart diagrams.	6
4.	Architectural Modeling: Component, Deployment, Component diagrams and Deployment diagrams. Common modeling techniques	6
	Total	**24**

Text Books:
1. Grady Booch, - The unified modeling language user guide. Pearson Education India, ISBN: 0-201-57168
2. James Rumbaugh. Micheal Blaha- Object-Oriented Modeling and Design with UML: Pearson Education India, ISBN-13: 978-0130159205

Reference Books:
2. Charles Ritcher - Designing Flexible Object-Oriented systems with UML. New Riders Publishing.
3. Jackson, Burd Thomson - Object Oriented Analysis & Design. Thomson Course Technology.
4. Mike O'Docherty - Object-Oriented Analysis and Design: using UML. Wiley Publication
5. Joseph Schmuilers - Teach Yourself UML in 24 Hours. Sams publishing.

Program:	M. Tech. (Civil) Construction Management				Semester :	I
Course :	Project Management and Finance				Code :	MCI1601A
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Pre-requisite: Basics of Management, Basics of Finance

Objectives:

After Completing this course, student will have adequate background to understand and solve the problem involving :Outline the principles followed in carrying out a project.

1. To demonstrate knowledge and understanding of engineering and management principles.
2. To function effectively as an individual, and as a member or leader in diverse teams.
4. To understand the concepts of finance and accounts carried out in project management.

Outcomes:

After learning the course, the students should be able to:

1. Study the current market trends and choose projects.
2. Prepare project feasibility reports.
3. Ability to implement the project effectively meeting government norms and conditions.
4. Ability to understand the role and responsibility of the Professional Engineer.
5. Ability to choose projects which benefit the society and organization.

Detailed Syllabus:

Unit	Description	Duration h
1	**Introduction to Management** What is Management? It's Need ,Importance & Purpose, Evolution of Managements thought, Different Schools/ approaches to Management: Behavioral, Quantitative, Systems, Contingency Approach	6
2.	**Project Implementation, Monitoring and Control** Project representation: Role of project managers, relevance with objective of organization, preliminary manipulations, Basic Scheduling concepts: Resource levelling, Resource allocation, Setting a base line, Project management information system: Importance of contracts in projects: Team work in Project Management: Formation of Effective terms.	6
3.	**Organizing** Organizing as a Management process, Principles of Organization, Different Structures of organizations such as line, Line & Staff, Functional, Matrix or project Organization: Characteristics, Features, their Merits and Limitation, Ownerships of Organization: Sole Proprietorship, Partnership, Private Ltd., Public Ltd., Introduction to Organizational climate, Decision Making, Group Decision Making, Staffing: What is Staffing? Steps involved in Staffing, Recruitment, Staffing, Performance Appraisal Development	6
4.	**Financial Statements and Their Analysis** Understanding of Financial Statements and Their Analysis, Like Balance Sheet, Profit & Loss Account ,Ratio Analysis, Fund Flow Analysis, Statement of Changes In Financial Position.	6
	Total	24

Text Books:

1. Project Management Institute A Guide to the Project Management Body of Knowledge PMBOK Guide (Sixth Edition), Sept 2017.
2. James C.Van Horne, Fundamentals of Financial Management, Person Education 2004.
3. Khanna, R.B.,Project Management, PHI 2011.

Reference Books:

1. Kuster J., Huber, E., Lippmann, R., Schmid, A., Schneider, E., Witschi, U., Wust, R. Project Management Handbook, 2015.

2. Prasanna Chandra, Financial Management, Tata McGraw-Hill, 2008.
3. Carl S. Warren, James M. Reeve, Jonathan Duchac.
4. Financial and Managerial Accounting, 2016
5. Paneer Selvam, R., and Senthilkumar, P., Project Management, PHI, 2011.

Program:	M. Tech. (Civil) Construction Management			Semester : I		
Course :	Green Technology			Code : MCI1601B		
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Pre-requisite:

1. Environmental study, Types of pollution

Objectives:

After Completing this course, student will have adequate background to understand and solve the problem involving:

1. To learn about Global warming and its effect
2. To demonstrate knowledge in the reduction of global warming.
3. To learn the control measures of carbon emission and accumulation.
4. To learn high tech measures for Reducing Carbon Emissions.

Outcomes:

After learning the course, the students should be able to:

1. Study the effects of Global warming
2. Implement the concept of reduction of global warming
3. Understand the remedial action for the carbon emission and accumulation.
4. Apply high tech measures for Reducing Carbon Emissions.

Detailed Syllabus:

Unit	Description	Duration h
1.	**Global Warming and its effect:-** Introduction and physical definition of global warming, the New Carbon Problem: Accumulation, Long Half-Life, Heating Potential, Carbon Emission Factors, Carbon Absorption in Nature, The Global Emission Situation and its effect in India, The Kyoto and Other Protocols and its view in India, Effect of climate change and its impact. **Planning for the Future to reduce global warming:-** Steps taken to Control Carbon Emissions universally, Use of Promotional and Punitive Mechanisms for Reducing Carbon in Atmosphere, The General Approach in Planning for the Future, Developing Countrywide Adaptive Measures for Safety of Local People, Developing Mitigative Measures for Global Reduction of Carbon, India's National Action Plan on Climate Change (NAPCC) till date, National Mission for a Green India, The MRV Debate.	6
2.	**Opportunities in Control of Carbon Emissions and Accumulation:-** Essential Steps for Control of Carbon Emissions and Accumulation, Procedure to develop own Priorities and Business Opportunities in India for control of carbon emissions and accumulation, Needs a Mix of Green and Traditional Power Sources in India, A Logical Approach for Carbon Reduction, Need in India —More Forests, Less Deforestation and payment rates procedure for controlling carbon emissions and its Promotional Mechanisms at India. **Green Technologies for Energy Production:-** Various Technologies Available for Energy Production, Cost Comparison of a Few Typical Systems for Power Generation, Sources of Energy Production Already in Use, Alternative Methods Ready for Use, Green Technologies Needing some Prior R&D Work.	6
3.	**Green Technologies for Personal and Citywide Application :-** Measures to be taken for Green city, Carbon Emission Reduction at Personal Level, Carbon Emission Reduction at Local Authority and Citywide Level, Carbon Emissions from Imports. **Green Technologies for Specific Applications:-** Promotion of 'Green' Buildings, Guidelines, The Energy Conservation Building Code (ECBC), Green Hotels and Hospitals, Green Technologies for Transport, Green Roads, Ports and Harbors, Industries, Carbon, Carbon Emissions from a Few Selected Industries in India, The Changing Scenario in Cities, Need for Wider Application to Town Planning and Area Re-Development Projects ,'Green' Infrastructure for Municipal Services, Bringing up Indian Villages, Green Services for Crematoria, Spreading Message to all Stakeholders.	6
4.	**Some High-tech Measures for Reducing Carbon Emissions :-** Use of Solar Power with Satellite-Based Systems ,Use of Carbon Capture and Storage (Sequestration) ,Microorganisms, A Quick SWOT Analysis.	6

	Recommended Plan of Action :- India's National Action Plan Take Us to a Low-Carbon Path, The Missions Help Develop Awareness, Few case studies on Projects undertaken by Various Countries, Adaptive Measures Essential for Indian People to Cope with Climate Change	
	Total	**24**
Text Books: 1. Green Technologies, Soli J. Arceivala, Mc Graw Hill Education.		
Reference Books 1. Green Technologies and Environmental Sustainability edited by Ritu Singh, Sanjeev Kumar 2. http://cpcbenvis.nic.in/greentechnology.html		

Program:	M. Tech. (Construction Management)				Semester : II	
Course :	Contracts, Tendering & Arbitration				Code : MCI2602A	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Pre-requisite: None

Objectives:

1. To equipped with knowledge of contracts system.
2. To study principles and specifications for making tender documents
3. To learn basic principles of Arbitration in the context of various construction aspects.

Outcomes:

After learning the course, the students should be able to:

3. Adopting the ethical knowledge for making construction contracts & Tenders.
4. Prepare Tendering documents as per conditions of contract.
5. Exhibit concept of Arbitration to resolution of disputes in construction projects.

Detailed Syllabus:

Unit	Description	Duration h
1.	**Construction Contracts:** Indian Contract Act (1872): Definition of the contract as per the ACT. Valid, Voidable, Void contracts, Objectives of the act. Introduction: To law, Indian legal system, Laws governing structure & Working of Construction Organization Firms, Laws of Tort.	6
2.	**Construction Contract Documents:** Evaluation of contract documents, need for documents, present stage of national and international contract documents, types of construction contracts, roles and functions of parties to the contract. Contract Formation.	6
3.	**Stages in Contracting:** Preparation of tender documents estimating, pre - qualification, bid evaluation, award of contract, project financing and contract payments, contracts close out and completion.	6
4.	**Arbitration:** Comparison of Actions and Laws - Agreements, subject matter-Violations-Appointment of Arbitrators-Conditions of Arbitrations-Powers and duties of	6
	Total	24

Text Books:

1. Civil Engineering Contracts and Estimates - B.S.Patil – Universities Press- 2006 Edition,reprinted in 2009.
2. The Indian Contract Act (9 of 1872), 1872- Bare Act- 2006 edition, Professional Book Publishers.
3. The Arbitration and Conciliation Act,(1996), 1996 (26 of 1996)- 2006 Edition, Professional Book Publisher.

Reference Books:

1. Law of contract Part I and Part II, Dr. R.K. Bangia- 2005 Edition, Allahabad Law Agency.
2. Arbitration, Conciliation and Alternative Dispute Resolution Systems- Dr. S.R. Myneni- 2004 Edition, reprinted in 2005- Asia Law House Publishers.
3. The Workmen‘s Compensation Act, 1923 (8 of 1923) Bare Act- 2005- Professional Book Publishers.
4. Standard General Conditions for Domestic Contracts- 2001 Ministry Of Statistics and Program Implementation, Government of India.
5. FIDIC Document (1999).
6. Dispute Resolution Board foundation manual-www.drbf.org. 30 Edition

Program:	M. Tech. (Civil) Construction Management				Semester :	II
Course :	Total Quality Management in Construction				Code :	MCI2602B
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	--	30	50

Pre-requisite: TQM & MIS at UG Level , Awareness of Quality Construction Aspects

Objectives:

1. To **understand** the need of QM in construction and **apply** necessary tools to achieve
2. To **apply** necessary trainings for the effective utilization of resources
3. To **apply** effectively the eight principles of ISO for quality processes in construction
4. To **apply** Six Sigma tool for TQM in construction project

Outcomes:

After learning the course, the engineers should be able to:

1. Understand and apply the TQM phylosophy in construction
2. Able to use effectively QC tools.
3. Apply ISO principles for effective Quality processes in construction
4. Able to apply Six Sigma effectively.

Detailed Syllabus:

Unit	Description	Duration h
1.	**Concepts of Quality** A) Definition of quality as given by Deming, Juran, Crosby, difference between Quality control, Quality Assurance (QA/QC). Total quality control (TQC) and Total Quality Management (TQM), Need for TQM in construction industry. Organization necessary for implementation of quality, Quality manual-Contents, data required, preparation, responsibility matrix, monitoring for quality- PDCA Cycle. Quality aspects in every phase in the life cycle of Construction project.	**6**
2.	**Quality Control Tools** Histogram, Pareto diagram, Fish-bone diagram, Quality control chart-Testing required for quality control of construction material used in RCC Work- destructive and Non destructive Test (NDT). Statistical Quality Control-Necessity, Benchmarking.	**6**
3.	**Study of ISO 9004- Quality System Standards.** Purpose of ISO Standards. Difference between ISO 9001 and ISO 9004. Certification process for ISO 9001. Certification bodies involved. Eight Principles of ISO-Basic meaning, applying these principles for an effective quality process in the organization. Management support and commitment necessary for achieving implementation for quality system standards. **Development** of quality circles, quality inspection team, inspection reports, monitoring and control, 360‘ feedback for quality.	**6**
4.	**A) Six Sigma** Definition of six sigma, evolution – Historical aspects, probability distribution Six sigma ratings, Six sigma training, six sigma as an effective tool in TQM. **B) Application of Six Sigma** i) RCC Work in building (ii) Assessment of overall construction process from concept to completion of a construction project.	**6**
	Total	**24**

Text Books:

1. Quality Control and Total Quality Management by P.L.Jain- Tata McGraw Hill Publ.Company Ltd
2.Total Engineering Quality Management – Sunil Sharma – Macmillan India Ltd.
3.Total Project Management – The Indian Context - P.K.Joy Macmillan India Ltd.

Reference Books:

1. International Standards Organization – ISO 9001 and ISO 9004
2. Mantri Handbook – A to Z of Construction – Mantri Publications
3. Juran‘s Quality Handbook – Joseph M. Juran, A. Blanton. Godfrey – Mcgraw Hill International Edition (1998)
4. Management Information Systems – Gordon B. Davis, Margrethe H. Olson – Tata McGraw Hill Publ. Co.

Program:	M. Tech. (Civil Engineering)				Semester : II	
Course :	OperationsResearch				Code : MCI2602C	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE2	ETE	Total
2	2	2	20	-	30	50

Pre-requisite: Applied Mathematics Including Calculus and Linear Algebra, Calculus-Based Probability/Statistics

Objectives: This course aims at enabling students,

1. To familiarize with concepts and techniques of Linear and Nonlinear Programming Problems.
2. To derive feasible and optimal solution for Transportation and Assignment Problem.
3. To apply various methods to select and execute various optimal strategies using decision theory.
4. To construct network diagrams with single and three time estimates of activities involved in the project.

Outcomes: After learning the course, the students should be able to:

1. Model and solve Linear and Nonlinear Programming Problems.
2. Model & Solve profit maximization Transportation and Assignment Problem.
3. Apply various methods to select and execute various optimal strategies using decision theory.
4. Calculate Project schedule and expected completion time for the project.

Detailed Syllabus:

Unit	Description	Duration h
1.	**Introduction to Operations Research** Introduction, operations research approach to problem solving, Models and Modelling in operations research, Advantages, Methods for solving operations research models, Methodology of operations research, Advantages. **Linear Programming** Introduction, Structure of Linear programming Model, Advantages, Limitations, Assumptions and Applications of Linear programming, Guidelines for Model Formulation, Solving Linear programming problems using Graphical Method and Simplex Method	6
2.	**Transportation and Assignment Problems** Mathematical Models of Transportation Problem, The Transportation Algorithm, Methods for Finding Initial Solution, Test for Optimality. Mathematical Models of Assignment Problem, Solution Methods of Assignment Problem.	6
3.	**Decision Theory and Games Theory** Steps of Decision-Making Process, Types of Decision-Making Environment, DecisionMaking Under Uncertainty, Games Theory**:** Introduction, Two Person Zero Sum Games, Pure Strategies (Minimax and Maximin Principles): Games with Saddle Point, Mixed Strategies: Games without Saddle Point, The Rules of Dominance, Solution Methods of Games without Saddle Point.	6
4.	**Project Management** Introduction, Basic Difference between PERT and CPM, Phases of Project Management, PERT/CPM Network Components and Precedence Relationships, Critical Path Analysis. Project scheduling with uncertain activity times, Estimation of project completion time.	6
	Total	24

Text Books:

1. J K Sharma, "Operations Research: Theory and Applications" , Trinity Press 5th Edition ISBN No. 9789350593363.
2. Frederick S. Hillier, Gerald Lieberman, "Introduction to Operations Research, McGraw Hill", 6th Edition ISBN No.0071139893.

Reference Books:

1. Gerald Lieberman, "Operations Research: An Introduction", PHI, 9th Edition, ISBN No. 978- 9332518223.
2. Gupta Prem Kumar and Hira D.S, "Problems in Operations Research", S. Chand, ISBN No.978- 8121909686.
3. Wayne L. Winston, "Operations Research Applications and Algorithms", Cengage Learning, 4th Edition, ISBN No. 978-8131501900.
4. P Sankara Iyer, "Operations Research", Sigma Series, TMH, 1st Edition, ISBN No.978-0070669024.

Program:	M. Tech. (Information Technology)			Semester : I		
Course :	Business Analytics			Code : MEIT1601A		
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	-	30	50

Pre-requisite: 1. Machine Learning; 2. Data Science

Objectives:

1. Understand the different basic concept / fundamentals of business statistics
2. Understand the concept of Probability and its usage in various business applications.
3. Understand the practical application of Descriptive and Inferential Statistics concepts and their uses for Business Analytics.
4. Evaluate different data analytics tools.

Outcomes:

After learning the course, the students should be able to:

1. Gaining Knowledge of basic concept / fundamentals of business analytics.
2. Evaluating basic concepts of probability and perform probability theoretical distributions.
3. To perform practical application by taking managerial decision and evaluating the Concept of Business Analytics.
4. Evaluate different tools.

Detailed Syllabus:

Unit	Description	Duration h
1.	**Introduction** What is business analytics?, Business Analytics process: problem framing, Data modeling, model building, Deployment, Different types of business analytics, application of business analytics, current trends, roles within data analytics team.	**6**
2.	**Analytics Techniques** Optimization techniques: Linear Programming, Goal Programming, Integer Programming, Non –linear programming, Predictive modeling :- regression, multiple linear regression for predictive analysis, logistic regression, linear discriminant analysis, Data Mining: Introduction to supervised and unsupervised learning, clustering	**6**
3.	**Probability Theory & Distribution** Probability: Theory of Probability, Addition and Multiplication Law, Baye's Theorem Probability Theoretical Distributions: Concept and application of Binomial; Poisson and Normal distributions. Concept of Business Analytics- Meaning types and application of Business Analytics, Use of Spread Sheet to analyze data-Descriptive analytics and Predictive analytics	**6**
4.	**Data analytics tools** Data Visualization using Tableau/Python/R/SQL. Case study.	**6**
	Total	**24**

Text Books:

1. R.N. Prasad ,Seema Acharya, "Fundamentals of business analytics", Wiley

Reference Books:

1. James Evans, Business Analytics, 2nd Edition, Pearson

Program:	M. Tech. (Information Technology)			Semester : I		
Course :	R Programming			Code : MEIT1601B		
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	-	30	50

Pre-requisite:
1. Knowledge of Statistics in Mathematics
2. Prior Knowledge of any programming

Objectives:
1. To use R and R Studio Environment
2. To understand different data types and control structures in R
3. To interface R with other languages.
4. To understand the use of R for Big Data analytics.

Outcomes:
After learning the course, the students should be able to:
1. Understand the basics in R programming in terms of constructs, control statements, string functions.
2. Apply the use of R for Big Data analytics.
3. Learn to apply R programming for Text processing.
4. Able to appreciate and apply the R programming from a statistical perspective.

Detailed Syllabus:

Unit	Description	Duration h
1.	**Getting Started with R Programming** Introduction to the R-Studio, user-interface, Basic commands, Data Structures in R, Reading data into R, Subsetting	6
2.	**Matrices, Arrays And Lists** Creating matrices ,Matrix operations ,Applying Functions to Matrix Rows and Columns, Adding and deleting rows and columns, Vector/Matrix Distinction, Avoiding Dimension Reduction, Higher Dimensional arrays, Lists, Creating lists, General list operations,– Accessing list components and values, Applying functions to lists, Recursive lists	6
3.	**Data Frames** Creating Data Frames, Matrix-like operations in frames, Merging Data Frames, Applying functions to Data frames, Factors and Tables: factors and levels, Common functions used with factors, Working with tables, Other factors and table related functions, Control statements: Arithmetic and Boolean operators and values, Default values for arguments, Returning Boolean values, Environment and Scope issues: Writing Upstairs - Recursion ,Replacement functions, Tools for composing function code, Math and Simulations in R	6
4.	**Interfacing** Interfacing R to other languages, Parallel R, Basic Statistics, Linear Model, Generalized Linear models, Non-linear models, Time Series and Auto-correlation – Clustering	6
	Total	24

Text Books:

1. Mark Gardener, Beginning R – The Statistical Programming Language, Wiley, 2013
2. Norman Matloff , The Art of R Programming: A Tour of Statistical Software Design, No Starch Press, 2011

Reference Books:

1. Jared P. Lander, R for Everyone: Advanced Analytics and Graphics, Addison-Wesley Data & Analytics Series, 2013
2. Robert Knell, Introductory R: A Beginner's Guide to Data Visualization, Statistical Analysis and Programming in R, Amazon Digital South Asia Services Inc, 2013.

Program:	M. Tech. (Information Technology)			Semester : I		
Course :	Cost Management of Engineering Project			Code : MEIT1601C		
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	-	30	50

Pre-requisite:
1. Software Engineering, 2. Project Management

Objectives:
1. To provide the parties concerned with a most favorable financial outcome to the project.
2. Identifying "best value" project option selection and developing realistic budgets.

Outcomes:
After learning the course, the students should be able to:
1. Prepare favorable financial outcome to the project.

Detailed Syllabus:

Unit	Description	Duration h
1.	**Introduction and Purpose of Project Cost Management** Client, Engineering consultant supporting Client in Development Phase, Engineering (Managing) Contractor carrying out EPCM role for project implementation, Consultant acting as PMC for Client, Material Suppliers, Construction / Service Contractors, External Finance Provider	**6**
2.	**Core Project Cost Management Issues** Project Concept & Feasibility, Project Development & Definition, Project Implementation, Project Commissioning & Financial Close out	**6**
3.	**Estimating and Project Financing** Estimate Categories, Estimate Quality, Project Schedule influence on estimated cost, Estimate Scope, Study / Development Estimates, Estimates for provision of advanced funding, Estimate quality required for project authorization, Estimating techniques, Location factors, Escalation ,Currency fluctuations, Contingency, Cash flow Project Financing: Internal financing, Financing of project development works, External financing, Banks & Venture Funds, Government grants and loans, Contractors, Suppliers, Customers	**6**
4.	**Vulnerable Projects** Mega-projects (Projects with value >€2Bn), Retrofit projects (Modifications and extensions to existing facilities), New Technology projects, Sub-surface works, Projects in emerging markets (e.g. E Europe, Asia), Projects in remote locations, Projects requiring significant regulatory validation (e.g. Pharmaceutical, Nuclear), Contaminated Demolition, Fast Track Projects	**6**
	Total	**24**

Text Books:
1. Kenneth K. Humphreys, Lloyd M. English, "Project and cost engineer's handbook", third edition, Ace International, Marcel Dekkar Inc., New York Basel.

Reference Books:
1. Kenneth K. Humphreys, Lloyd M. English, "Project and cost engineer's handbook", third edition, Ace International, Marcel Dekkar Inc., New York Basel.

Program:	M. Tech. (Information Technology)			Semester : II		
Course :	Cryptography			Code : MEIT2602A		
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	-	30	50

Pre-requisite:
1. Basic Mathematics
2. Basic Computer Network.

1. To understand computer, network and information security.
2. To study operating system security and malwares.
3. To study security issues in internet protocols.
4. To study network defense tools.

Outcomes:
After learning the course, the students should be able to:
1. Understand modern concepts related to cryptography and cryptanalysis
2. Analyze and use methods for cryptography and reflect about limits and applicability of these methods
3. Learn details and design philosophy of modern symmetric and public key systems
4. Learn uses and limitations of the various categories of cryptographic algorithms

Detailed Syllabus:

Unit	Description	Duration h
1.	**Introduction:** Computer Security Concepts, Terminology, OSI Security Architecture, Elements Of Information Security, Security Policy, Types of Security attacks , Security Goals and services, Modular Arithmetic, GCD, Euclidean Algorithm, Fermat's Little Theorem, Euler Totient Function, Extended Euclidean Algorithm, Chinese Remainder Theorem.	6
2.	**Classical Encryption Techniques:** Symmetric Cipher Model, Encryption Methods, Classical Encryption Techniques, Substitution Ciphers, Transposition Ciphers, one-time pad, Cryptanalysis, Block Ciphers, Stream Ciphers	6
3.	**Private-key Encryption:** Block Cipher Principles, Data Encryption Standard (DES), Triple DES, Advanced Encryption Standard (AES), RC5, International Data Encryption Algorithm (IDEA), Differential and Linear cryptanalysis	6
4.	**Public-key cryptosystems:** Public-Key Cryptography, Key Management, Key Distribution, RSA, Timing Attack, Diffie Hellman Key Exchange, Elliptic Curve Arithmetic, Elliptic Curve Cryptography [ECC]	6
	Total	24

Text Books:

1. William Stallings, Computer Security: Principles and Practices, Pearson 6th Ed, ISBN: 978-0-13-335469-0
2. V. K. Pachghare, "Cryptography and Information Security", PHI Learning 3rd edition
3. Jonathan Katz, Yehuda Lindell, "Introduction to Modern Cryptography", CRC press

Reference Books:

1. Oded Goldreich, Foundations of Cryptography Basic Tools, Cambridge University Press.
2. Nina Godbole, Information Systems Security, Wiley India Pvt. Ltd, ISBN -978-81-265-1692-6

Program:	M. Tech. (Information Technology)			Semester : II		
Course :	Cloud Computing and Security			Code : MEIT2602B		
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	-	30	50

Pre-requisite:
1. Operating Systems
2. Fundamentals of Computer Networks.

Objectives:
1. To become familiar with Cloud Computing and its ecosystem.
2. To learn basics of virtualization and its importance.
3. To give technical overview of Cloud Programming and Services.
4. To understand security issues in cloud computing.

Outcomes:
After learning the course, the students should be able to:
1. To understand the need of Cloud based solutions.
2. To understand Security Mechanisms and issues in various Cloud Applications
3. To explore effective techniques to program Cloud Systems.
4. To understand current challenges and trade-offs in Cloud Computing..

Detailed Syllabus:

Unit	Description	Duration h
1.	**Fundamentals of cloud computing:** Origins and Influences, Basic Concepts and Terminology, Goals and Benefits, Risks and Challenges, Roles and Boundaries, Cloud Characteristics, Cloud Delivery Models, Cloud Deployment Models, Federated Cloud/Intercloud, Types of Clouds. Cloud-Enabling Technology: Broadband Networks and Internet Architecture, Data Center Technology, Virtualization Technology, Web Technology, Multitenant Technology, Service Technology.	6
2.	**Virtualization and common standards in cloud computing:** Implementation Levels of Virtualization, Virtualization Structures/Tools and Mechanisms, Types of Hypervisors, Virtualization of CPU, Memory, and I/O Devices, Virtual Clusters and Resource Management, Virtualization for Data-Center Automation. Common Standards: The Open Cloud Consortium, Open Virtualization Format, Standards for Application Developers: Browsers (Ajax), Data (XML, JSON), Solution Stacks (LAMP and LAPP),Syndication (Atom, Atom Publishing Protocol, and RSS), Standards for Security	6
3.	**Cloud programming, environments and applications: :** Features of Cloud and Grid Platforms, Programming Support of Google App Engine, Programming on Amazon AWS and Microsoft Azure, Emerging Cloud Software Environments, Understanding Core OpenStack Ecosystem. Applications: Moving application to cloud, Microsoft Cloud Services, Google Cloud Applications, Amazon Cloud Services, Cloud Applications (Social Networking, E-mail, Office Services, Google Apps, Customer Relationship Management).	6
4.	**Cloud security and issues:** Basic Terms and Concepts, Threat Agents, Cloud Security Threats and Attacks, Additional Considerations, Cloud Security Mechanisms: Encryption, Hashing, Digital Signature, Public Key Infrastructure (PKI), Identity and Access Management (IAM), Single Sign-On (SSO), Hardened Virtual Server Images. Cloud Issues: Stability, Partner Quality, Longevity, Business Continuity, Service-Level Agreements, Agreeing on the Service of Clouds, Solving Problems, Quality of Service, Regulatory Issues and Accountability.	6
	Total	24

Text Books:

1. Jack J. Dongarra, Kai Hwang, Geoffrey C. Fox, Distributed and Cloud Computing: From Parallel Processing to the Internet of Things, Elsevier, ISBN :9789381269237, 9381269238, 1st Edition.
2. Thomas Erl, Zaigham Mahmood and Ricardo Puttini, Cloud Computing: Concepts, Technology & Architecture, Pearson, ISBN :978 9332535923, 9332535922, 1 st Edition.

Reference Books:

1. Srinivasan, J. Suresh, Cloud Computing: A practical approach for learning and implementation, Pearson, ISBN :9788131776513.
2. Brian J.S. Chee and Curtis Franklin, Jr., Cloud Computing: Technologies and Strategies of the Ubiquitous Data Center, CRC Press, ISBN :9781439806128.
3. Kris Jamsa, Cloud Computing: Saas, Paas, Iaas, Virtualization, Business Models, Mobile, Security, and More, Jones and Bartlett, ISBN :9789380853772.
4. John W. Ritting house, James F. Ransome, Cloud Computing Implementation, Management, and Security, CRC Press, ISBN : 978 1439806807, 1439806802.
5. Karl Matthias, Sean P. Kane, Docker: Up and Running, OReilly, ISBN:9781491917572, 1491917571.

Program:	M. Tech. (Information Technology)			Semester : II		
Course :	Bitcoin : Fundamentals of Crypto Currencies			Code : MEIT2602C		
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
2	2	2	20	-	30	50

Pre-requisite:
1. Basic of Cryptography
2. Basic of Information and Cyber security.

Objectives:
1. To understand the basic concepts behind Cryptography and Crypto currency.
2. To understand the different Consensus approaches for Bit coin.
3. To understand the concepts of blockchain technology.
4. To understand the Mechanics of bit coin.

Outcomes:
After learning the course, the students should be able to:
1. Apply Cryptography concepts to Currency (real time) problem solving.
2. Learn and apply different consensus mechanisms for real time projects based on digital currency.
3. Analyze block chain model come from a different case studies.

Detailed Syllabus:

Unit	Description	Duration h
1.	**Basics** Fundamentals of Crypto currencies : Nodes, Transaction , Wallets, Coin Mining ,Basics of Trading Exchanges ,Market Tradability Crypto Trading Strategies, Blockchain: Nodes, P2P , Ledger ,Consensus Methods Genesis Block	**6**
2.	**How to Store and Use Bit coins** How to Store and Use Bit coins, Hot and Cold Storage, Splitting and Sharing Keys, Online Wallets and Exchanges, Payment Services, Transaction Fees, Currency Exchange Market	**6**
3.	**Cryptography:** Cryptographic Hash Functions: Hashing and SHA 256, Digital Signatures, Public Keys , Private Keys, A Simple Crypto currency	**6**
4.	**Mechanics of Bit coin** Bit coin Transactions, Bit coin Scripts, Applications of Bit coin Scripts, Bit coin Blocks, The Bit coin Network, How Bit coin Achieves Decentralization, Centralization vs. Decentralization, Distributed Consensus : Consensus without Identity, The Block chain Incentives, Miners and Mining :Proof of Work ,Limitations & Improvements.	**6**
	Total	**24**

Text Books:
1. Martin Quest, "Block chain Dynamics: A Quick Beginner's Guide on Understanding the Foundations of Bit coin and Other Crypto currencies", Create Space Independent Publishing Platform, 15-May-2018
2. Daniel Drescher, "Block chain Basics", A Non -Technical Introduction in 25 Steps.

Reference Books:
1. Bikramaditya Singhal, Gautam Dhameja, Priyansu Sekhar Panda, "Beginning Block chain A Beginner's Guide to Building Block chain Solutions", 2018
2. 2. Chris Dannen , "Introducing Ethereum and Solidity", Foundations of Crypto currency and Block chain Programming for Beginners

Annexure-II

Audit Courses

Program:	**M.Tech Mechanical (Heat Power Engineering)**				**Semester:**	**I and II**
Course :	**Audit Courses (Semester I and II)**				**Code:**	M_1961 M_2962
Teaching Scheme			**Evaluation Scheme**			
Lecture	**Hours**	**Credit**	**IE1**	**IE2**	**ETE**	**Total**
1	1	--	--	--	--	--

Guidelines:

1. The audit courses are common to all M. Tech programs
2. Students can select any audit course from list of audit courses for Semester I and II
3. These are non-credit courses but mandatory to comply the submission of the semester.

Program:	M.Tech Mechanical (Heat Power Engineering)				Semester : I	
Course :	Constitution of India				Code : M_1961A	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
1	1	-	--	--	--	--

Objectives:

1. To understand the constitution and the centre-state relations and functioning
2. To understand the rules and regulations under which public and private sector work
3. To understand E-governance through computers and knowledge of cyber laws

Outcomes:

After learning the course, the students should be able to:

1. Work cohesively without violating the rules and regulations of the constitution
2. Understanding and application of E-governance for suitable projects

Detailed Syllabus:

Unit	Description	Duration h
1.	Introduction to Constitution of India; Salient Features of the Constitution; Fundamental Rights and Fundamental Duties; Directive Principles of State Policy Role of Public Sector Undertakings in economic development; Need for Reformed Engineering Serving at the Union and State level	6
2.	E-Governance and Role of engineers in E-Governance; Finance Commission and Centre-State Relations; Role of I.T. professionals in Judiciary; Cyber laws in India	6
	Total	12

Text Books:

1. Brij Kishore Sharma: An Introduction to the Constitution of India, Eighth Edition. PHI Learning, 2011
2. C.S.Prabhu: E-Governance, Concepts and Case Studies

Reference Books:

1. Dr J N Pandey : Constitutional Law of India
2. https://www.meity.gov.in/divisions/national-e-governance-plan
2. https://www.meity.gov.in/DeitY_e-book/e-gov_policy/download/Policy%20Document.pdf
3. http://www.iibf.org.in/documents/cyber-laws-chapter-in-legal-aspects-book.pdf

Program:	M.Tech. Mechanical (Heat Power Engineering)				Semester : I	
Course :	Value Education				Code : M_1961B	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
1	1	-	--	--	--	--

Objectives:

1. To identify and develop Attitude and Core Faith values
2. To expose students to Family Relations
3. To enable student to understand Creative Thinking and Problem solving
4. To enable students to understand Humanistic Education.

Outcomes:

After learning the course the students should be able to:

1. Change in awareness levels, knowledge and understanding of student
2. Change in attitudes / behavior of students with regards to their education improved teamwork, institutional leadership and other life skills
3. Improvement in social health and attitude.

Detailed Syllabus:

Unit	Description	Duration h
1	Why Human Relations are so important? Understanding Behavior, Human Relations, and Performance, Personality, Stress, Learning, and Perception, Attitudes, Self-Concept, Natural acceptance of human values, and Ethics, Dealing with Conflict, Leading and Trust	6
2	Justice in Humankind, Nurturing and Exploitation, Definitiveness of Ethical Human Conduct, Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order, Competence in professional ethics	6
	Total	12

Text Books:

1. A Foundation Course in Human Values and Professional Ethics" R R Gaur, R Sangal, G P Bagaria, Excel Books, New Delhi and Teacher's Manual, R R Gaur, R Sangal, G P Bagaria, Excel Books, New Delhi

Reference Books:

1. Human Relations in Organizations Applications and Skill Building" Robart Lussier, eighth edition, McGraw-Hill (2014).
2. Atkinson and Hilgard's, "Introduction to psychology" Nolen-Hoeksema, S., Fredrickson, B. L., Loftus, G. R., & Lutz, C., Cengage Learning EME.

Program:	M.Tech. Mechanical (Heat Power Engineering)			Semester :	I
Course :	Stress Management			Code :	M_1961C

Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
1	1	-	--	--	--	--

Objectives:

1. To overcome stress
2. To achieve overall health of body and mind
3. To learn to achieve the highest goal happily
4. To become a person with stable mind, pleasing personality and determination

Outcomes:

Students will be able to:

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

Detailed Syllabus:

Unit	Description	Duration h
3.	Definitions of Eight parts of Yog. (Ashtanga) Yam and Niyam. Do`s and Don't's in life.	6
2.	Pranayam Regularization of breathing techniques and its effects- Types of pranayama Approach to day to day work and duties, wisdom	6
	Total	12

Text Books:

1. Yogic Asanas for Group Tarining-Part-I" : Janardan Swami Yogabhyasi Mandal, Nagpur

Reference Books:

1. Swami Vivekananda, Rajayoga or conquering the Internal Nature, Advaita Ashrama (Publication Department), Kolkata
2. Wendelin Küpers, David J. Pauleen, A Handbook of Practical Wisdom Leadership, Organization and Integral Business Practice, 2016
3. A Foundation Course in Human Values and Professional Ethics Presenting a Universal Approach to Value Education - Through Self-exploration

Program:	M. Tech. Mechanical (Heat Power Engineering)				Semester: II	
Course:	Team Building & Leadership				Code: M_2962A	
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE 1	IE 2	ETE	Total
1	1	-	--	--	--	--

Objectives:

1. Develop and strengthen interpersonal skills
2. Become familiar with and discuss different leadership models.
3. Familiarize students with the characteristics of team building.

Outcomes:

After learning the course, the students should be able to:

1. Use leadership and teamwork knowledge to develop projects.
2. To develop the capacity to work collaboratively in a team

Detailed Syllabus:

Unit	Description	Duration h
4.	**Leadership:** Will and motivation, Personal leadership, self-knowledge, and self-control, using power responsibly and respectfully: the leader as a team-builder, Ability to plan future actions and transmit that vision to others. Taking the initiative and stimulate others. What the word "leader" means, Types of leadership, Traditional, legal, and legitimate leader. Categories: autocratic, democratic, charismatic, paternalistic, authentic, spiritual, dictatorial, etc	6
2.	**Team work** Why is teamwork important? The evolution from group to team: development stages. Advantages and disadvantages of teamwork. How to determine roles in a team. Traditional vs. virtuoso teams, forming effective and balanced teams, Strengthening teams within the organization. Creating a friendly and collaborative environment. Strategies to develop the team's mission, vision, values, and objectives. Shared objectives vs. personal motivation. Distinguishing purpose and tasks in the team. Encouraging participation. Creating team identity, creating high-performing teams.	6
	Total	12

Text Books

1. Stephen Covey, The Seven Habits of Highly Effective People, Free Press, 1989.
2. Ronald A. Heifetz, Leadership without Easy Answers, Belknap Press, 1994.
3. Michael E. Porter, Competitive Strategy, Free Press, 1980.

Reference Books:

1. John Kotter, Leading Change: Why Transformation Efforts Fail,
2. Ikujiro Nonaka, The Knowledge-Creating Company
3. Michael West, The Secrets of Successful Team Management, Chap. 2, "Self-Management," pgs. 32-61

Program: M.Tech Mechanical (Heat Power Engineering)				**Semester :** II		
Course : English For Research Paper Writing				**Code :** M_2962B		
Teaching Scheme			**Evaluation Scheme**			
Lecture	**Hours**	**Credit**	**IE1**	**IE2**	**ETE**	**Total**
1	**1**	**-**	**--**	**--**	**--**	**--**

Objectives:

1. Understand that how to improve your writing skills and level of readability
2. Learn about what to write in each section
3. Understand the skills needed when writing a Title
4. Ensure the good quality of paper at very first-time submission

Outcomes:

After learning the course the students should be able to:

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

Detailed Syllabus:

Unit	Description	Duration h
1	Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness, Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.	**6**
2	key skills are needed when writing a Title, Abstract, Introduction, Review of the Literature, Methods, Results, Discussion, Conclusions useful phrases, how to ensure paper is as good as it could possibly be the first- time submission	**6**
	Total	**12**

Text Books:

1. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press

Reference Books:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book .
3. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

Program:	M.Tech. Mechanical (Heat Power Engineering)			Semester : II		
Course :	Disaster Management			Code : M_2962C		
Teaching Scheme			Evaluation Scheme			
Lecture	Hours	Credit	IE1	IE2	ETE	Total
1	1	-	--	--	--	--

Objectives:

1. To orient engineers about various natural and manmade disasters.
2. To teach the concept of Disaster management and measures to be taken at different stages of disaster management.
3. To provide insight about global, national and regional level scenario of disaster management.

Outcomes:

After learning the course the students should be able to:

1. Learn different disasters and measures to reduce the risk due to these disasters.
2. Learn institutional frame work for disaster management at national as well as global level.

Detailed Syllabus:

Unit	Description	Duration h
1.	**Introduction** – Hazard and Disaster. Concepts of Hazard, Vulnerability, Risks. Different Types of Disaster : A) Natural Disaster: such as Flood, Cyclone, Earthquakes, Landslides etc B) Man-made Disaster: such as Fire, Industrial Pollution, Nuclear Disaster, Biological Disasters, Accidents (Air, Sea, Rail & Road), Structural failures(Building and Bridge), War & Terrorism etc. Slow Disasters (famine, draught, epidemics) and Rapid Onset Disasters(Air Crash, tidal waves, Tsunami) Causes, effects and practical examples for all disasters.	6
2.	**Natural disasters**- Earthquakes, Tsunami, Floods, Drought, Landslides, Cyclones and Volcanic eruptions. Their case studies. Coastal disasters. Coastal regulation Zone. **Disaster Prevention and Mitigation**. Refugee operations during disasters, Human Resettlement and Rehabilitation issues during and after disasters, Inter-sectoral coordination during disasters, Models in Disasters. **Disaster Management** : Role of Government, International and NGO Bodies. Role of IT in Disaster Preparedness Role of Engineers on Disaster Management.	6
	Total	12

Reference Books:

1. Pandey, M., 2014. Disaster Management, Wiley India Pvt. Ltd., 240p.
2. Tushar Bhattacharya, Disaster Science and Management, McGraw Hill Education (India) Pvt. Ltd
3. Jagbir Singh, Disaster, Management: Future Challenges and Opportunities, K W Publishers Pvt. Ltd.
4. J.P. Singhal, Disaster Management, Laxmi Publications
5. C. K. Rajan, Navale Pandharinath, Earth and Atmospheric Disaster Management : Nature and Manmade, B S Publication
6. Shailesh Shukla, Shamna Hussain, Biodiversity, Environment and Disaster Management, Unique Publications

Text Books:

1. Disaster Administration and Management, Text & Case studies- SL Goel-Deep and Deep Publications
2. Disaster Management- G.K Ghosh-A.P.H. Publishing Corporation
3. Disaster management – S.K.Singh, S.C. Kundu, Shobha Singh A – 119, William Publications, New Delhi.
4. Disaster Management – Vinod K Sharma- IIPA, New Delhi,1995
5. Encyclopedia of Disaster Management- Goel S.L. - Deep and Deep Publications, New Delhi, 2006.

VISION AND MISSION OF MECHANICAL DEPARTMENT

Vision

- To recognize for an academic excellence through skill development, innovation fine blend with quality work culture

Mission

- To impart quality education, innovation culture, necessary skill sets and social commitment among the students to build professional carrier by establishing state-of-the-art Mechanical Engineering infrastructure and conducive learning environment

Programme outcomes:

1. An ability to independently carry out research /investigation and development work to solve practical problems
2. An ability to write and present a substantial technical report/document
3. Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

Programme Specific Outcomes:

1. Students will be able to critically analyse / synthesize, simulate and optimize mechanical systems, components and processes by applying the principles of thermal engineering.
2. Student will be able to investigate and provide solutions to complex interdisciplinary problems using modern tools of thermal engineering.

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- Mechanical Engineering

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"There are no secrets to success. It is the result of preparation, hard work, learning from failure."

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