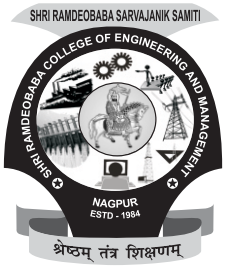

SHRI RAMDEOBABA COLLEGE OF ENGINEERING AND MANAGEMENT, NAGPUR – 440013

An Autonomous College affiliated to
Rashtrasant Tukadoji Maharaj Nagpur University,
Nagpur, Maharashtra (INDIA)

PROGRAMME SCHEME & SYLLABI
2021 – 2022

B. Tech. (MECHANICAL ENGINEERING)

Published By

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ISO 9001 : 2015 CERTIFIED ORGANISATION

Department Vision

Department of Mechanical Engineering aims to inculcate in students, a flair for excellence to become technological leader in industry and society.

Department Mission

1. To create the learning environment that stimulates students & faculty to enhance the knowledge in Mechanical Engineering.
2. To prepare the students to carry out research intended to cater the needs of the industry and society.
3. To march ahead with dedication, zeal and with a system responsive to the needs of all the stakeholders.

Program Educational Objectives

1. The graduates shall be capable to accept challenges in Engineering industries.
2. The graduates shall demonstrate core competency to design, analyze and evaluate various engineering systems.
3. The graduates shall be able to apply computational and professional skills in corporate world.
4. The program shall prepare the graduates for higher studies, entrepreneurship and create awareness about lifelong learning.

Program Outcomes

Engineering Graduates will be able to :

1) **Engineering Knowledge :** Apply the knowledge of Mathematics, Science, Engineering fundamentals, and engineering specialization to the solution of complex engineering problems.
2) **Problem Analysis :** Identify, Formulate, Review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3) **Design / development of Solutions :** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal and environmental considerations.
4) **Conduct investigation of complex problems :** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of the information to provide valid conclusions.
5) **Modern Tool Usage :** Create, select and apply appropriate techniques resources and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6) **The Engineer and society :** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7) **Environment and Sustainability :** Understand the impact of the professional engineering solutions in societal and environmental contexts and demonstrate the knowledge of, and need for sustainable development.

8) **Ethics :** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9) **Individual and Team work :** Function effectively as an individual, and as a member or leader in diverse teams, and in multi disciplinary settings.

10) **Communication :** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentations, make effective presentations, and give and receive clear instructions.

11) **Project management and Finance :** Demonstrate knowledge and understanding of the engineering and management principles and apply these to ones own work, as a member and leader in a team to manage projects and in multidisciplinary environment.

12) **Life-long Learning :** Recognize the need for and have the preparation and ability to engage in independent and life long learning in the broadest context of technological change.

Programme Specific Outcomes

1) Graduates will stand for design, production and operations in core mechanical domain and management of interdisciplinary applications.

2) Graduates will be capable of carrying out the analysis of mechanical and allied systems and provide numerical and computer based solution.

Teaching Scheme for First Year (Semester I & II) Bachelor of Engineering
Group 1 : Semester - I / Group 2 : Semester - II

Sr. No.	Code	Course	Hours/week			Credits	Maximum marks			ESE Duration (Hrs)
			L	T	P		Continuous Evaluation	End Sem Exam	Total	
1.	PHT152	Oscillations, waves & Optics	3	1	0	4	40	60	100	03
2.	PHP152	Oscillations, Waves & Optics Lab	0	0	3	1.5	25	25	50	–
3.	MAT152/ MAT151	Differential Equations, Linear Algebra, Statistics & Probability/ Calculus	3	0/1	0	3/4	40	60	100	03
4.	MAP151	Computational Mathematics Lab	0	0	2	1	25	25	50	–
5.	EET151	Basic Electrical Engineering	3	1	0	4	40	60	100	03
6.	EEP151	Basic Electrical Engineering Lab	0	0	2	1	25	25	50	–
7.	MET151	Engineering Graphics & Design	1	0	0	1	40	60	100	03
8.	MEP151	Engineering Graphics & Design Lab	0	0	4	2	50	50	100	–
9.	HUT152	Constitution of India	2	0	0	0	–	–	–	–
10.	PEP151	Yoga / Sports	0	0	2	0	–	–	–	–
		TOTAL	**12**	**2/3**	**13**	**17.5/18.5**			**650**	

Group 2 : Semester - 1 / Group 1 : Semester - II

Sr. No.	Code	Course	Hours/week			Credits	Maximum marks			ESE Duration (Hrs)
			L	T	P		Continuous Evaluation	End Sem Exam	Total	
1.	CHT151	Chemistry	3	1	0	4	40	60	100	03
2.	CHP151	Chemistry Lab	0	0	3	1.5	25	25	50	–
3.	MAT151/ MAT152	Calculus/Differencial Equations, Linear Algebra, Statistics	3	1/0	0	4/3	40	60	100	03
4.	CST151	Programming for Problem Solving	4	0	0	4	40	60	100	03
5.	CSP151	Programming for Problem Solving Lab	0	0	2	1	25	25	50	–
6.	IDT151	Creativity, Innovation & Design Thinking	1	0	0	1	20	30	50	1.5
7.	INT151	Workshop/Manufacturing Practices Lab	1	0	0	1	20	30	50	1.5
8.	INP151	Workshop/Manufacturing Practices Lab	0	0	2	1	25	25	50	–
9.	HUT151	English	2	0	0	2	40	60	100	03
10.	HUP151	English Lab	0	0	2	1	25	25	50	–
		TOTAL	**14**	**2/1**	**9**	**20.5/19.5**			**700**	

Scheme of Teaching & Examination of Bachelor of Engineering (Mechanical Engineering)

Semester III

Sr. No.	Course code	Course Name	Hours/week			Credits	Maximum marks			ESE Duration (Hrs)
			L	T	P		Continuous Evaluation	End Sem Exam	Total	
1.	MET251	Materials Engineering	3	0	0	3.00	40	60	100	3 Hrs.
2.	MEP251	Materials Engineering	0	0	1	0.50	25	25	50	-
3.	MEP252	M/C Drawing & Solid Modeling	0	0	2	1.00	50	50	100	-
4.	MET253	Engineering Mechanics	3	0	0	3.00	40	60	100	3 Hrs.
5.	MET254	Manufacturing Processes	3	0	0	3.00	40	60	100	3 Hrs.
6.	MEP254	Manufacturing Processes	0	0	2	1.00	25	25	50	-
7.	MAT257	Engineering Mathematics	3	1	0	4.00	40	60	100	3 Hrs.
8.	IDT251	Biology	2	0	0	2.00	40	60	100	3 Hrs.
9.	MEP260	Industry Visit	0	0	2	0.00	-	-	-	-
		Total	**14**	**1**	**7**	**17.5**			**700**	

Semester IV

Sr. No.	Course code	Course Name	Hours/week			Credits	Maximum marks			ESE Duration (Hrs)
			L	T	P		Continuous Evaluation	End Sem Exam	Total	
1.	MET261	Kinematics & Dynamics of Machinery	3	1	0	4	40	60	100	3 Hrs.
2.	MEP261	Kinematics & Dynamics of Machinery Lab	0	0	2	1	25	25	50	-
3.	MET262	Thermodynamics	3	1	0	4	40	60	100	3 Hrs.
4.	MET263	Strength of Materials	3	1	0	4	40	60	100	3 Hrs.
5.	MET264	Fluid Mechanics & Hydraulic Machines	3	1	0	4	40	60	100	3 Hrs.
6.	MEP264	Fluid Mechanics & Hydraulic Machines Lab	0	0	2	1	25	25	50	-
7.	MEP265	Mechanical Engineering Software Lab	0	0	2	1	25	25	50	-
8.	MET299	Open Elective - I	3	0	0	3	40	60	100	3 Hrs.
9.	CHT252	Environmental Science	2	0	0	0	-	-	-	-
10.	MEP270	Mini Project	0	0	2	0	-	-	-	-
		Total	**17**	**4**	**8**	**22**			**650**	

Open Elective - I	
Course Code	**Course Name**
MET299-1	Basic Mechanical Engineering
MET299-2	Non Conventional Energy Sources

Scheme of Teaching & Examination of Bachelor of Engineering
(Mechanical Engineering)
Semester V

Sr. No.	Course code	Course Name	Hours/week			Credits	Maximum marks			ESE Duration (Hrs)
			L	T	P		Continuous Evaluation	End Sem Exam	Total	
1.	MET351	Applied Thermodynamics-I	3	1	0	4	40	60	100	3 Hrs.
2.	MET352	Heat Transfer	3	0	0	3	40	60	100	3 Hrs.
3.	MEP352	Heat Transfer	0	0	2	1	25	25	50	-
4.	MET353	Design of Machine Elements-I	3	1	0	4	40	60	100	3 Hrs.
5.	MET354	Manufacturing Technology	3	0	0	3	40	60	100	3 Hrs.
6.	MEP354	Manufacturing Technology	0	0	2	1	25	25	50	-
7.	MET355	Operations Research	3	0	0	3	40	60	100	3 Hrs.
8.	MET398	Open Elective - II	3	0	0	3	40	60	100	3 Hrs.
9.	HUT353	Indian Traditional Knowledge	2	0	0	0	-	-	SF/USF	-
10.	MEP360	Project-I	0	0	2	1	50	-	50	-
		Total	**20**	**2**	**6**	**23**			**750**	

Open Elective - II	
Course Code	**Course Name**
MET398-1	Project Management
MET398-2	Automobile Engineering

Semester VI

Sr. No.	Course code	Course Name	Hours/week			Credits	Maximum marks			ESE Duration (Hrs)
			L	T	P		Continuous Evaluation	End Sem Exam	Total	
1.	MET361	Applied Thermodynamics-II	3	0	0	3.00	40	60	100	3 Hrs.
2.	MEP361	Applied Thermodynamics-II	0	0	2	1.00	25	25	50	-
3.	MET362	Instrumentation & Control	3	0	0	3.00	40	60	100	3 Hrs.
4.	MEP362	Instrumentation & Control	0	0	1	0.50	25	25	50	-
5.	MET363	Finite Element Analysis	2	0	0	2.00	40	60	100	3 Hrs.
6.	MEP363	Finite Element Analysis	0	0	2	1.00	25	25	50	-
7.	MEP364	Design of Machine Elements-II	0	0	2	1.00	25	25	50	-
8.	MET365	Elective-I	3	0	0	3.00	40	60	100	3 Hrs.
9.	MEP365	Elective-I Lab	0	0	1	0.50	25	25	50	-
10.	MET366	Elective-II	3	0	0	3.00	40	60	100	3 Hrs.
11.	MET399	Open Elective – III	3	0	0	3.00	40	60	100	3 Hrs.
12	MEP368	Comprehensive Viva Voce	0	0	2	1.00	25	25	50	-
13.	MEP370	Project-II	0	0	2	1.00	50	-	50	-
		Total	**17**	**0**	**12**	**23.00**			**950**	

Elective - I			
Code Code	**Course Name**	**Code Code**	**Course Name**
MET365-1	Introduction to Computational Fluid Dynamics	MEP365-1	Introduction to Computational Fluid Dynamics
MET365-2	Internal Combustion Engines	MEP365-2	Internal Combustion Engines
MET365-3	Computer Graphics	MEP365-3	Computer Graphics
MET365-4	Synthesis of Mechanisms	MEP365-4	Synthesis of Mechanisms
MET365-5	Soft Computing Techniques in Mechanical Engineering	MEP365-5	Soft Computing Techniques in Mechanical Engineering
MET365-6	Additive Manufacturing	MEP365-6	Additive Manufacturing
MET365-7	Mechatronic Systems	MEP365-7	Mechatronic Systems

Elective - II			
Code Code	**Course Name**	**Code Code**	**Course Name**
MET366-1	Advanced Manufacturing Techniques	MET366-2	Industrial Fluid Power
MET366-3	Automobile Engineering	MET366-4	Dynamics of Machinery
MET366-5	Numerical Methods for Mechanical Engineering		

Open Elective - III	
Code Code	**Course Name**
MET399-1	World Class Manufacturing
MET399-2	Safety and Hazard Analysis
MET399-3	Energy Auditing

Scheme of Teaching & Examination of Bachelor of Engineering (Mechanical Engineering)

Semester VII

Sr. No.	Course code	Course Name	Hours/week			Credits	Maximum marks			ESE Duration (Hrs)
			L	T	P		Conti-nuous Evaluation	End Sem Exam	Total	
1.	MET451	Elective-III	3	0	0	3.00	40	60	100	3 Hrs.
2.	MEP451	Elective-III Lab	0	0	1	0.50	25	25	50	-
3.	MET452	Elective-IV	3	0	0	3.00	40	60	100	3 Hrs.
4.	MET453	Elective-V	3	0	0	3.00	40	60	100	3 Hrs.
5.	MET454	Elective-VI	3	0	0	3.00	40	60	100	3 Hrs.
6.	MET498	Open Elective – IV	3	0	0	3.00	40	60	100	3 Hrs.
7.	MEP455	Internship Evaluation (6 to 8 Week)	0	0	2	0.00	-	-	-	-
8.	MEP460	Project-III	0	0	10	5.00	100	100	200	-
		Total	**15**	**0**	**13**	**20.5**			**750**	

Elective - III			
Code Code	**Course Name**	**Code Code**	**Course Name**
MET451-1	Stress Analysis	MEP451-1	Stress Analysis Lab
MET451-2	Advanced Finite Element Methods	MEP451-2	Advanced Finite Element Methods Lab
MET451-3	Industrial Robotics	MEP451-3	Industrial Robotics Lab
MET451-4	Refrigeration and Air-conditioning	MEP451-4	Refrigeration and Air-conditioning Lab
MET451-5	Renewable Energy Systems	MEP451-5	Renewable Energy Systems Lab
MET451-6	IoT and Industry 4.0	MEP451-6	IoT and Industry 4.0 Lab

Elective - IV			
Code Code	**Course Name**	**Code Code**	**Course Name**
MET452-1	Mechanical Vibrations	MET452-2	Power Plant Engineering
MET452-3	Vehicle Dynamics	MET452-4	Supply Chain Management
MET452-5	Energy Conservation and Management	MET452-6	Micro machining

Elective - V			
Code Code	**Course Name**	**Code Code**	**Course Name**
MET453-1	Control Systems	MET453-2	Principles of Management
MET453-3	Electric Vehicle Technology	MET453-4	Composite Materials
MET453-5	Advanced Heat Transfer	MET453-6	Mobile Robotics

Elective - VI			
Code Code	**Course Name**	**Code Code**	**Course Name**
MET454-1	Design of Mechanical Systems	MET454-2	MEMS
MET454-3	Engineering Economics and Cost Estimation	MET454-4	Material Handling Systems
MET454-5	Project Management	MET454-6	Artificial Intelligence and Expert System

Open Elective - IV	
Code Code	**Course Name**
MET498-1	Mechatronics
MET498-2	Industrial Robotics
MET498-3	Functional Safety
MET498-4	Condition Monitoring
MET498-5	Steam and Hydro Turbines

Scheme of Teaching & Examination of Bachelor of Engineering (Mechanical Engineering)

Semester VIII

Sr. No.	Course code	Course Name	Hours/week			Credits	Maximum marks			ESE Duration (Hrs)
			L	T	P		Conti-nuous Evaluation	End Sem Exam	Total	
1.	MET461	Elective-VII	3	0	0	3.00	40	60	100	3 Hrs.
2.	MET462	Elective-VIII	3	0	0	3.00	40	60	100	3 Hrs.
3.	MET463	Elective-IX	3	0	0	3.00	40	60	100	3 Hrs.
4.	MEP463	Elective-IX Lab	0	0	2	1.00	25	25	50	-
5.	MEP470	Project –IV/ Industry Project	0	0	12	6.00	150	150	300	-
		Total	**9**	**0**	**14**	**16.00**			650	
OR										
6.	MEP471	Full Semester Internship (Research/Industry/TBI)	-	-	-	**16.00**	**100**	**100**	**200**	-

Elective - VII

Course Code	Course Name
MET461-1	Industrial Management and Entrepreneurship Development
MET461-2	Lean Production System
MET461-3	Reliability Engineering

Elective - VIII

Course Code	Course Name
MET462-1	Productivity Improvement Techniques
MET462-2	Field and Service Robots
MET462-3	Marketing Management

Elective - IX

Course Code	Course Name	Course Code	Course Name
MET463-1	Automation in Manufacturing	MEP463-1	Automation in Manufacturing Lab
MET463-2	Product Lifecycle Management	MEP463-2	Product Lifecycle Management Lab
MET463-3	Human Factors in Engineering	MEP463-3	Human Factors in Engineering Lab

Scheme of Teaching & Examination of Bachelor of Engineering
Honors Specialization (Mechanical Engineering)

Sr. No.	Course code	Course Name	Hours/week			Credits	Maximum marks			ESE Duration (Hrs)
			L	T	P		Conti-nuous Evaluation	End Sem Exam	Total	
1.	METH41	Digital Manufacturing	4	0	0	4.00	40	60	100	3 Hrs.
2.	METH51	Tool Design	4	0	0	4.00	40	60	100	3 Hrs.
3.	METH61	Turbo Machinery	4	0	0	4.00	40	60	100	3 Hrs.
4.	METH71	Design of Heat Exchangers	4	0	0	4.00	40	60	100	3 Hrs.
5.	METH81-1	Tribology	4	0	0	4.00	40	60	100	3 Hrs.
6.	METH81-2	Robotics	4	0	0	4.00	40	60	100	3 Hrs.

Scheme of Teaching & Examination of Bachelor of Engineering
Minors Specialization (Mechanical Engineering)

Sr. No.	Course code	Course Name	Hours/week			Credits	Maximum marks			ESE Duration (Hrs)
			L	T	P		Conti-nuous Evaluation	End Sem Exam	Total	
1.	METM41	Automotive Engineering	4	0	0	4.00	40	60	100	3 Hrs.
2.	METM51	Computer Aided Design	4	0	0	4.00	40	60	100	3 Hrs.
3.	METM61	Automation and Robotics	4	0	0	4.00	40	60	100	3 Hrs.
4.	METM71	Solar Energy Technology	4	0	0	4.00	40	60	100	3 Hrs.
5.	METM81-1	Manufacturing Engineering	4	0	0	4.00	40	60	100	3 Hrs.
6.	METM81-2	Mechanical Engineering Design	4	0	0	4.00	40	60	100	3 Hrs.

Semester I / II
Department of Mechanical Engineering

Course Code : PHT152 **Course : Oscillations, Waves, Optics**

L:3 Hrs.,T:1Hrs.,P:0Hrs.,Per week **Total Credits : 4**

Course Objectives

1. To train the student to work with oscillatory phenomena in electrical, mechanical and optical systems.
2. To introduce fundamental concepts and laws as relevant to electromagnetic waves and matterwaves.

Course Outcomes

After successful completion of the course students will understand and be able to work with

1. Free, damped and forced oscillations;
2. Fundamental properties of mechanical waves and their propagation across material boundaries;
3. Phenomena of interference, diffraction of optical waves;
4. Elementary understanding of quantum behavior of electrons in solids.

Module 1 : Oscillations (8L)

Quick review of simple harmonic motion, mechanical and electrical oscillators, vector and complex number (phasor) representation, superposition of many SHMs of equal amplitude and equal succesive phase difference; Damped oscillations, under, critical and over-damping with stress on mechanical oscillators, problems; Forced oscillations with focus on mechanical oscillations, impedance of a mechanical circuit, forcing frequency dependence of velocity, displacement in a forced oscillator, two components of displacement, energy and power supplied by driving force, Q factor.

Module 2 : Waves - 1 (5L)

Correlated harmonic oscillations in space and time, statement and meaning of the wave equation, general solution, concept of polarization of waves - transverse and longitudinal waves; Transverse wave on a string, characteristic impedance, reflection and transmission at a string-string boundary, impedance matching, insertion of quarter-waveelement.

Module 3 : Waves - 2 (5L)

Group of waves, group velocity, meaning of dispersion, causes of dispersion; Standing waves, normal modes of vibrating string, energy in modes, standing wave ratio; Longitudinal waves: sound waves in gases, statement and meaning of expressions for energy distribution and intensity.

Module 4: Wave Optics - 1 (6L)

Light as a transverse polarized electromagnetic wave in vacuum and in homogeneous isotropicdielectric, impedance E / H E Poynting vector, energy; Reflection and refraction of em wave at dielectric-dielectric boundary, parallel and perpendicular polarizations, boundary conditions on Eand H components, Fresnel equations, Brewster's angle.

Module 5 : WaveOptics-2(6L)

Huygens' principle, superposition, interference by division of amplitude and wave front, Young's double- slit, Newton's rings, Michels on interferometer; Single-slit Fraunho fer diffraction, Ray leigh criterion for resolution, grating and its resolving power.

Module 6 : Matter Waves (8L)

Plank's energy packets, Wave-particle duality of de Broglie, Heisenberg uncertainty relations; Wave function, Ψ for matter waves and its interpretation, position and momentum operators, Hamiltonian operator, Schrodinger's equation; One-dimensional single particle systems: Particle in an infinite square well potential (rigid box), finite square well potential; Quantum tunneling.

Text Book(s)

1. The Physics of Vibrations and Waves(Sixth Edition), HJ Pain John-Wiley2005.
2. Optics, Ajoy Ghatak Tata McGraw Hill Education 2005

References

1. Online course: Oscillations and Waves by S Bharadwaj on NPTEL
2. Engineering Physics (Second Edition), Sanjay Jain and Girish Sahasrabudhe, Universities Press2016.

Semester I / II
Department of Mechanical Engineering

Course Code : PHP152 **Course : Oscillations, Waves, Optics Lab**

L: 0Hrs.T:0Hrs.P:3Hrs.Per week **Total Credits :1.5**

Course Outcomes

The Physics Laboratory course will consist of experiments illustrating the principles of physics relevant to the study of science and engineering. Students will show that they have learnt laboratory skills that will enable them to properly acquire and analyze the data in physics laboratory and draw valid conclusions. At the end of the Course the students will learn to:

1. Develop skills to impart practical knowledge in realtime.
2. Understand principle, concept, working and application of areas in physics and compare the results obtained with theoretical calculations.
3. Understand measurement technique, and report the results obtained through proper graph plotting and error analysis.

In addition to the demo experiments, the Lab turns will be utilized for performing the experiments based on the following lists as specific to Program:

1. Error analysis and graph plotting
2. Wave length, frequency and phase velocity of travelling wave.
3. Wave length of source of light using Newton's rings
4. To study the oscillation in bifilar suspension arrangement
5. Determination of velocity of sound in liquid–standingultrasonicwaves as optical grating
6. Kundt' stube– Determination of the wave length of sound with the cork powder method
7. Determination of velocity of sound in solid
8. Beating of ultra sonic waves
9. Investigation of Doppler effect with ultrasonic waves
10. Refractive Index of prism
11. Frequency, amplitude and phase determination using C.R.O.
12. Study of surface flat nessusing interference phenomena
13. To determine the resolving power of grating
14. Study of Polarizers and Analyzers
15. Study of total internal reflection using Laser source
16. Data analysis using Mathematica

Suggested References

1. Physics Lab Manual written by the Teaching Faculty of Physics Department, RCOEM.A minimum of 8 experiment sare to beper formed from the above list of experiments.

Semester I / II
Department of Mechanical Engineering

Course Code : MAT151 **Course : Calculus**

L: 3 Hrs., T: 1 Hrs., P: 0 Hrs., Per week **Total Credits : 04**

Course Objective

The objective of this course is to familiarize the prospective engineers with techniques in Calculus and multivariate analysis. It aims to equip the students with standard concepts and tools at an intermediate to advanced level that will serve them well towards tackling more advanced level of mathematics and applications that they would find useful in their disciplines.

Course Outcomes

On successful completion of the course, the students will learn:

1. The fallouts of Mean Valve Theorems that is fundamental to application of analysis to Engineering problems, to deal with functions of several variables that are essential in most branches of engineering.
2. Basics of improper integrals, Beta and Gamma functions, Curve Tracing, tool of power series and Fourier series for learning advanced Engineering Mathematics.
3. Multivariable Integral Calculus and Vector Calculus and their applications to Engineering problems.

Syllabus

Module - I : Differential Calculus: (12hours)

Taylor's and Maclaurin's series expansions; radius of curvature (Cartesian form), evolutes and involutes, Limit and continuity of functions of several variables and their partial derivatives, Eulers Theorem, chain rule, total derivative, Jacobians, Maxima, minima and saddle points; Method of Lagrange multipliers.

Module - II : Integral Calculus: (6 hours)

Evaluation of definite and improper integrals; Beta and Gamma functions and their properties; Tracing of curves (Cartesian form)

Module - IV : Sequences and series: (7 hours)

Convergence of sequence and series, tests for convergence, power series, Fourier series: Half range sine and cosine series, Parseval's theorem.

Module - V : Multiple Integrals (10 hours)

Multiple Integration: Double and triple integrals (Cartesian and polar), change of order of integration in double integrals, Change of variables (Cartesian to polar), Applications: area, mass and volume by double integration, Center of mass and Gravity (basic concepts).

Module - VI : Vector Calculus (10 hours)

Vector Differentiation, Directional derivatives, total derivative, Gradient, Curl and Divergence. Vector integration , Theorems of Green, Gauss and Stokes and their applications.

Topics for self learning

Rolle's theorem, Mean value theorems, Indeterminate forms , Maxima and minima for function of one variable, Geometrical interpretation of Partial Differentiation(Tangent plane and Normal line) , Applications of definite integrals to evaluate perimeter, area, surface areas and volumes of revolutions.

Textbooks/References

1. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
2. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
3. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2000.
4. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11th Reprint, 2010.
5. P. N. Wartikar and J. N. Wartikar, A text book of Applied Mathematics Volume I & II, Pune Vidhyarthi Griha Prakashan, Pune-411030 (India).

Semester I / II
Department of Mechanical Engineering

Course Code : MAT152 **Course : Differential Equation, Linear Algebra, Statistics & Probability**

L: 3 Hrs, T: 0 Hr., P: 0 Hrs Per Week **Total Credits : 3**

Course Objective

The objective of this course is to familiarize the prospective engineers with techniques in Ordinary differential equation, statistics, probability and Matrices.

It aims to equip the students to deal with advanced level of mathematics and applications that would be essential for their disciplines.

Course Outcomes

On successful completion of the course, the students will learn:

1. The effective mathematical tools for the solutions of ordinary differential equations that model physical processes.
2. The essential tool of matrices in a comprehensive manner.
3. The ideas of probability and various discrete and continuous probability distributions and the basic ideas of statistics including measures of central tendency, correlation and regression.

Syllabus

Module 1 : First order ordinary differential equations(7 hours)

Exact, linear and Bernoulli's equations, Euler's equations, Equations not of first degree: equations solvable for p, equations solvable for y, equations solvable for x and Clairaut's type.

Module 2 : Ordinary differential equations of higher orders (8 hours)

Second order linear differential equations with constant and variable coefficients, method of variation of parameters, Cauchy-Euler equation.

Module 3 : Basic Statistics: (7 hours)

Curve fitting by the method of least squares- fitting of straight lines, second degree parabolas and moregeneral curves, correlation and regression – Rank correlation, Multiple regression and correlation.

Module 4 : Basic Probability: (8 hours)

Probability spaces, conditional probability, independence; Discrete random variables, Binomial distribution, Poisson distribution, Normal distribution. Relation between binomial, Poisson and Normal distributions.

Module 5 : Matrices (10 hours)

Algebra of matrices, Inverse and rank of a matrix, rank-nullity theorem; System of linear equations; Symmetric, skew-symmetric and orthogonal matrices; Eigen values and eigenvectors; Diagonalization of matrices; Cayley-Hamilton Theorem, Orthogonal transformation and quadratic to canonical forms.Topics for Self Learning

Application of Differential Equations.

Textbooks/References

1. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
2. W. E. Boyce and R. C. DiPrima, Elementary Differential Equations and Boundary Value Problems, 9th Edition, Wiley India, 2009.
3. S. L. Ross, Differential Equations, 3rd Ed., Wiley India, 1984.
4. E. A. Coddington, An Introduction to Ordinary Differential Equations, Prentice Hall India, 1995.
5. E. L. Ince, Ordinary Differential Equations, Dover Publications, 1958.
6. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2000.
7. Theory and Problems of probability and statistics : 2nded :J. R. Spiegal ,Schaum series
8. A text book of Applied Mathematics Volume I & II, by P. N. Wartikar and J. N. Wartikar, Pune Vidhyarthi Griha Prakashan, Pune-411030 (India).
9. S. Ross, A First Course in Probability, 6th Ed., Pearson Education India, 2002.

Semester I/II
Department of Mechanical Engineering

Course Code : MAP151 | **Course : Computational Mathematics Lab**

L:0Hr.,T:0Hrs.,P:2Hrs.,Perweek | **Total Credits : 1**

Course Outcomes

The Computational Mathematics Lab course will consist of experiments demonstrating the principles of mathematics relevant to the study of science and engineering. Students will show that they have learnt laboratory skills that will enable them to properly acquire and analyze the data in the lab and draw valid conclusions. At the end of the Course the students will learn to:

1. Develop skills to impart practical knowledge in realtime.
2. Understand principle, concept, working and application of areas in mathematics and comparethe results obtained with theoretical calculations.
3. Understand basics of mathematics, and report the results obtained through proper programming.

The Lab turns will be utilized for performing the experiments based on the following list:

1. Calculus
2. Ordinary Differential Equations
3. Statistics
4. Linear Algebra

Suggested References

1. Computational Mathematics Lab Manual written by the Teaching Faculty of Mathematics Department, RCOEM.

A minimum of 8 experiments to be performed based on the above list.

Semester I / II
Department of Mechanical Engineering

Course Code : EET151 **Course : Basic Electrical Engineering**

L: 3 Hrs. T: 1 Hrs. P: 0 Hrs. Per week **Total Credits : 4**

Course Outcomes

At the end of this course, students will demonstrate the ability

CO1: To understand and analyze basic electric and magnetic circuits.CO2: To study the working principles of electrical machines.

CO3: To study the working principles of power converters.

CO4: To introduce the components of power systems and low-voltage electrical installations.

Module 1 : Introduction to Power system (2 hours)– CO4

Introduction to Power Generation (Thermal, Hydro, Nuclear, Wind, and Solar) with block schematic presentation only. Single line diagram for Generation, Transmission & Distribution through different voltage levels.

Module 2 : DC Circuits & Magnetic Circuits(8 hours) - CO1

Electrical circuit elements (R, L and C), voltage and current sources, Kirchoff's current and voltage laws, analysis of simple circuits with dc excitation, Time-domain analysis of first order RL and RC circuits, Magnetic materials, BH characteristics, Basics of Magnetic circuits.

Module 3 : Single Phase AC Circuits (6 hours) - CO1

Representation of sinusoidal waveforms, peak and rms values, phasor representation, real power, reactive power, apparent power, power factor. Analysis of single-phaseaccircuitsconsisting of R, L, C, RL, RC, RLC combinations (series and parallel), resonance.

Module 4 : Three Phase AC Circuits (4 hours) - CO1

Three phase Ac generation, Three phase balanced circuits, voltage, and current relations in star and delta connections. Power factor improvement.

Module 5 : Transformers (6 hours) - CO2

Ideal and practical transformer, Equivalent circuit, losses in transformers, regulation, and efficiency. Auto transformer and three-phasetransformer connections.

Module 6 : Electrical Machines (8 hours) - CO2

Generation of rotating magnetic fields, Construction and working of a three-phase induction motor, Significance of torque-slip characteristic. Loss components, efficiency, starting of induction motor. Single- phase induction motor. Construction, working, torque-speed characteristic, and speed control of separately excited dc motor.

Module 7 : Power Converters (4 hours) - CO3

Block schematic introduction to power converters and its practical applications (DC-DC, DC-AC, AC-DC, AC- AC), Types of Batteries, Important Characteristics for Batteries and battery backup.

Module 8 : Electrical Installations (4 hours) - CO4

Components of LT Switchgear: Switch Fuse Unit (SFU), MCB, ELCB, MCCB, Types of Wires and Cables, Earthing. Elementary calculations for energy consumption, energy tariff.

Text / References

1. D. P. Kothariand I. J. Nagrath, "Basic Electrical Engineering", Tata McGraw Hill, 2010.
2. D. C. Kulshreshtha, "Basic Electrical Engineering", Mc Graw Hill, 2009.3. L. S. Bobrow, "Fundamentals of Electrical Engineering", Oxford University Press, 2011.
4. E. Hughes, "Electrical and Electronics Technology", Pearson, 2010.
5. V. D. Toro,"Electrical Engineering Fundamentals", Prentice Hall India, 1989.
6. Electrical Technology: B. L. Thereja, S. Chand Publications.
7. Basic Electrical Engineering: S. B. Bodkhe, N. M. Deshkar, P. P. H. Pvt. Ltd.

Semester I / II
Department of Mechanical Engineering

Course Code : EEP151 **Course : Basic Electrical Engineering Lab.**

L: 0 Hrs. T: 0 Hrs. P: 2 Hrs. Per week **Total Credits : 1**

Laboratory Outcomes

The students are expected to

CO1: Get an exposure to common electrical components and their ratings.

CO2 : Make electrical connections by wires of appropriate ratings.

CO3 : Understand the usage of common electrical measuring instruments.

CO4 : Understand the basic characteristics of transformers and electrical

CO5: Get an exposure to the working of power electronic converters.

List of Laboratory Experiments/Demonstrations

1. Basic safety precautions. Introduction & use of measuring instruments – voltmeter, ammeter, multi- meter, oscilloscope. Real-life resistors, capacitors and inductors.
2. Measuring the steady-state and transient time-response of R-L, R-C, and R-L-C circuits to a stepchange in voltage (transient may be observed on a storage oscilloscope).Sinusoidal steady stateresponse of R-L, and R-C circuits – impedance calculation and verification.

Observation of phase differences between current and voltage.

3. Transformers : Observation of the no-load current waveform on an oscilloscope (non sinusoidal wave- shape due to B-H curve non linearity should be shown along with a discussion aboutharmonics). Loading of a transformer: measure men to f primary and secondary voltages and currents, and power.
4. Star and Delta connections. Voltage and Current relationships (line-line voltage, phase-toneutralvoltage, line and phase currents). Cumulative three-phasepower in balanced three-phasecircuits.
5. Demonstration of cut-out sections of machines: dc machine (commutator-brusharrangement), induction machine (squirrel cage rotor), synchronous machine (field winding - slip ring arrangement) and single- phase induction machine.
6. Torque Speed Characteristic of dc shunt motor.
7. Synchronous speed of two and four-pole, three-phase induction motors. Direction reversal by change of phase- sequence of connections.
8. Demonstration of(a) dc-dcconverters(b) dc-acconverters–PWMwaveform(c)the use of dc-ac converter for speed control of an induction motor and(d) Components of LT switchgear.

Semester I / II
Department of Mechanical Engineering

Course Code : MET151 **Course : Engineering Graphics and Design**

L:1Hr.,T:0Hrs.,P:0 Hrs.,Per week **Total Credits : 01**

Course Outcomes

The expected learning outcome is that, the students shall be able to

1. Draw and interpret technical drawing
2. Convert 2-D to 3-D drawing and vice versa.
3. Represent the various positions of planes and solids in different orientations.
4. Develop the solid surface for sheet metal working.

UNIT - I : Introduction to Engineering Drawing

Principles of Engineering Graphics and their significance, usage of drawing instruments, Lettering and dimensioning.

UNIT - II : Orthographic Projections

Principles of Orthographic Projections -Conventions : Projections of Points and lines (line inclined to both planes) Projections of planes(inclined to both the planes), Introduction to Auxiliary Planes.

UNIT - III : Projections of Solids

Inclined to both the Planes. Auxiliary Views; Draw simple annotation, dimensioning and scale. Floor plans that include: windows, doors, and fixtures such as WC, bath, sink, shower, etc.

UNIT - IV : Sections and Sectional Views of Right Angular Solids

Prism, Cylinder, Pyramid Cone-Auxiliary Views; Development of surface of Right Regular solids - Prism, Pyramid, Cylinder and Cone; Draw the sectional orthographic views of geometrical solids, objects from industry and dwellings (foundation to slab only)

UNIT - V : Isometric Projections

Principles of Isometric projection - Isometric Scale, Isometric Views, Conventions; Isometric Views of Simple Solids; Conversion of Orthographic views to Isometric Views / Projection.

Suggested Text / Reference Books

i) Bhatt N. D. Panchal V.M. & Ingle P.R.,(2014) Engineering Drawing, Charotar Publishing House.

ii) Jolhe D. A. (2016) Engineering Drawing with an Introduction to Auto CAD", Tata McGraw- Hill Publishing Co. Ltd., New Delhi.

iii) Narayana K. L. & P. Kannaiah (2008), Text book on Engineering Drawing, Scitech Publishers.

iv) Shah M. B. & Rana B. C. (2008), Engineering Drawing and Computer Graphics, Pearson Education.

v) Agrawal B & Agrawal C. M. (2012), Engineering Graphic, TMH Publication.

vi) Corresponding set of CAD Software Theory and User Manuals.

Semester I / II
Department of Mechanical Engineering

Course Code : MEP151 **Course : Engineering Graphics & Design Lab**

L:0Hr.,T:0 Hrs.,P:4Hrs.,Per week **Total Credits : 02**

Course Outcomes

Students are prepared for actual work situations through practical training in a new state of the art computer designed CAD laboratory using engineering software. The student will learn to :

1. Draw and interpret technical drawing.
2. Plan the sheet layout for the given drawing.
3. Convert 2-D to 3-D drawing and viceversa.
4. Represent the various positions of planes and solids in different orientations.
5. Develop the solid surface for sheet metal working.
6. Use & demonstrate drafting package.

UNIT - I : Introduction to Engineering Drawing

Conic sections including the Rectangular Hyperbola (General method only); Cycloid, Epicycloids, Hypocycloid and involutes; Introduction to Scales.

UNIT - II : Orthographic Projections

Principles of Orthographic Projections-Conventions - Projections of Points and lines inclined to both planes; Projections of planes- Auxiliary Planes.

UNIT - III : Projections of Solids

Inclined to both the Planes Auxiliary Views; Draw simple annotation, dimensioning and scale, Floor plans that include: windows, doors, and fixtures such as WC, bath, sink, shower etc.

UNIT - IV : Sections and Sectional Views of Right Angular Solids

Prism Cylinder, Pyramid, Cone - Auxilary Views; Development of surfaces of Right Regular Solids Prism, Pyramid, Cylinder and Cone; Draw the sectional orthographic views of geometrical solids, objects from industryand dwellings (foundation to slab only)

UNIT - V : Isometric Projections

Principles of Isometric projection - Isometric Scale, Isometric Views, Conventions; Isometric Views of Simple Solids; conversion of Orthographic views to Isometric views Projection

UNIT - VI : Overview of Computer Graphics

Demonstrating knowledge of the theory of CAD software such as (the Menu System Toolbars Standard, Object Properties, Draw, Modify and Dimension), Drawing Area (Background, cross hairs, Coordinate Systems), Dialog boxes and windows, Shortcut menus (Button Bars), The command Line

(wherever applicable), The Status Bar, Different methods of zoom as used in CAD, select and erase objects; Isometric Views of lines, Planes, Simple and compound solids);

UNIT - VII : Customization & CAD Drawing

Setting up drawing page and the printer, including scale settings, Setting up of units and Drawing limits; ISO and ANSI standards for coordinate dimensioning; Orthographic constraints, map to objects, manually and automatically, Producing drawings by using various coordinate input entry methods to draw straight lines, Applying various ways of drawing circles;

UNIT - VIII : Annotations Layering & Other Functions

Applying dimensions to objects, applying annotations to drawings; Changing line lengths through modifying existing lines (extend/lengthen); Printing documents to paper using the print command; orthographic projection techniques.

UNIT - IX : Demonstration of a simple team design project that illustrates

Geometry and Topology of Engineered Components Creation of Engineering models and their presentation in standard 2D blueprint form and as 3D wire-frame and shaded solids; Meshed toplogies for engineering, Introduction to Building Information Modeling (BIM), Drafting and Design Package, 3D Printing.

List of sheets

1. Curves(ellipse, Parabola, hyperbola, Cycloid, involute)
2. Line, Planes, Solids
3. Application of Section and development of solids
4. Orthographic Projection
5. Isometric
6. Auto CAD practice sheet 1
7. Auto CAD practice sheet 2
8. Blueprint sheet

Suggested Text/ Reference Books

i) Bhatt N. D. Panchal V. M. & Ingle P.R.,(2014), Engineering drawing, Charotar Publishing house

ii) Jolhe D.A.,(2016) Engineering drawing with an Introduction to Auto CAD", Tata McGraw- Hill Publishing Co. Ltd., New Delhi.

iii) Shah M.B.& Rana B.C.(2008), Engineering drawing and Computer Graphic, Pearson Education.

iv) Agarwal B & Agarwal C.M. (2012), Engineering Graphics, TMH PUBLICATION

v) Narayana K. L & P Kannaiah (2008), Text Book on Engineering Drawing, Scitech Publishers.

vi) (Corresponding set of) CAD Software Theory and USER Manuals.

Semester I / II
Department of Mechanical Engineering

Course Code : HUT152 **Course : Constitution of India**

L:2Hrs.T:0Hrs.P:0Hrs.Per weeks **Total Credits : 0**

Course Outcome

1. Students will understand the role of constitution in democratic India
2. Students will be responsible students by knowing their fundamental rights and duties
3. Students will develop better understanding of democratic functions of the government of India
4. Students will form better understanding of system of governance for effective participation

Course Content

1. Meaning of the constitution law and constitutionalism
2. Historical perspective of the Constitution of India
3. Salient features and characteristics of the Constitution of India
4. Scheme of the Fundamental Rights
5. The scheme of the Fundamental Duties and its legal status
6. The Directive Principles of State Policy– Its importance and implementation
7. Federal structure and distribution of legislative and financial powers between the Union and the States.
8. Parliamentary Form of Government in India – The constitution powers and status of the President of India.
9. Union Executive: structure, functions
10. Judiciary: Structure, role with special reference to PIL, writ petitions, strengthening of democracy& social justice
11. Amendment of the Constitutional Powers and Procedure
12. Emergency Provisions: National Emergency, President Rule, Financial Emergency
13. Local Self Government – Constitutional Scheme in India
14. Provisions of civil services: Characteristics, functions, merits and demerits
15. Democratic principles in industry

Book

1. Durga Das Basu "An Introduction to Constitution of India" 22nd Edition, Lexis Nexis

Semester I / II
Department of Mechanical Engineering

Course Code : PEP151 **Course : Yoga / Sports**

L:0Hrs.T:0Hrs.P:2Hrs.Per week **Total Credits : 0**

Course Outcome

On successful completion of the course, students will be able to:

1. Understand fundamental skills and basic rules of games offered by the Physical Education Department ofRCOEM.
2. Obtained health related physical fitness.
3. Develop body-mind co-ordination through games and yoga.
4. Changed sedentary life styles towards active living.

Brief Objectives of Sports / Yoga Practical Classes

It has long been proven that a healthy body leads to a healthy mind. With a strong belief in this, Physical Education Department at RCOEM will conduct Sports/Yoga Classes with the objective of maintaining health, fitness and wellness of students as well as create awareness about need for good health and physical fitness. The objective would also be to make the all-round development with team spirit, social values as well as to identify and develop leadership qualities in students through various sports activities. Sports activities would also be conducted with the objective to provide better interaction and recreation to the students which is an important neutralizer for stress. Additionally, the objective would be to evaluate the health related fitness of students so as to recommend and conduct specific Yoga and Sports activities. The emphasis is on participation, with healthy competition.

Programme Outline

- **Sports**

1. Introduction to sports, offered by the department.
2. Health and safety issues related to sports; knowledge, recognition and ability to deal with injuries and illness associated with sports.
3. Practicing the fundamental skills and bringing awareness of basic rules and regulations.
4. Conduction of small recreational games and activities.

- **Yoga :** Includes various sitting, standing and lying Asanas, Suryanamaskars and Pranayamas.
- **Physical Efficiency Tests :** This includes 6 health related physical fitness tests.

Components	Name of Tests
Speed	50 mts Dash
Agility	Shuttle run
Cardiovascular Endurance	8 mins Run/Walk
Test Flexibility	Sit and Reach Test
Abdominal Strength (M)/Shoulder strength (F)	Bent Knee Sit-ups (M)/Modified Pull-ups (F)
Yogic exercises	Suryanamaskars

Semester I / II

Department of Mechanical Engineering

Course Code : CHT151 **Course : Chemistry**

L: 3Hrs., T: 1 Hrs., P: 0 Hrs., Per week **Total Credits : 4**

Course Outcomes

The concepts developed in this course will aid in quantification of several concepts in chemistry that have been introduced at the 10 + 2 levels in schools. Technology is being increasingly based on the electronic, atomic and molecular level modifications. Quantum theory is more than 100 years old and to understand different phenomena; one has to base the description of all chemical processes at molecular levels. The course will enable the student to:

- Explain the differences in the behavior of engineering materials based upon bond type, structure, composition, and processing.
- Analyse microscopic chemistry in terms of atomic and molecular orbitals and to apply this knowledge for understanding the band structure of different types of solids.
- Understand different types of molecular interactions, rationalise bulk properties and processes using thermodynamic considerations.
- Distinguish the ranges of the electromagnetic spectrum used for exciting different molecular energy levels in various spectroscopic techniques
- List major chemical reactions that are used in the synthesis of molecules and to understand structural aspect of organic compounds.
- Analyse impurities present in the water and suggest the methodology for its removal.

Chemistry (Concepts in Chemistry for Engineering)

(1) Engineering Materials (8 Lectures) : Polymeric Materials : Introduction, polymer composites, fibre reinforced composites, Biopolymers (Polylactic acid etc.). Engineering applications of polymers (optical media, data storage, devices, electronics and medical sector).

Nanomaterials : Definition of Nano, Top down bottom up approach, carbon age-new form of carbon (CNT to Graphene), One dimensional, Two dimensional and Three dimensional nanostructured materials, mechanical-physical-chemical, optical properties.Applications of Nanomaterials.

Cement : Raw materials, manufacturing of cement, properties (settling and hardening, heat of hydration, soundness), Types of cement, Rapid hardening, Pozzolonic cement, white cement, High Alumina Cement.

(2) Atomic and molecular structure (8 lectures) : Schroedinger equation. Particle in box solutions, Forms of the hydrogen atom wave functions and the plots of these functions to explore their spatial variations. Equations for atomic and molecular orbitals. Molecular Orbital Theory and Molecular orbital diagrams of different homo-nuclear and hetero-nuclear diatomic molecules. Pi- molecular orbital diagram of butadiene benzeneand hexatriene.

Crystal field theory and the energy level diagrams for octahedral and tetrahedral complexes of transition metal ions and their magnetic properties.

Band structure of solids and the role of doping on band structures.

(3) Spectroscopic techniques and applications (8 lectures) : Electromagnetic Spectrum, Principles of spectroscopy.

Electronic spectroscopy – Basic Principles, Lambert-Beer's Law, Woodward-Fisher Rule for conjugated dienes.

Fluorescence and its applications in medicine.

Nuclear magnetic resonance – Basic Principles, Chemical Shift, Spectral interpretation of some simple compounds.

(4) Chemical Thermodynamics and Corrosion Science(6 lectures) : Thermodynamic functions: energy, work, entropy, ethalpy and free energy and numerical based on these thermodynamic functions.

Corrosion – Basic principle, mechanism of corrosion, overview of types of corrosion and preventive measures.

(5) Stereo chemistry and Organic Reactions (8 lectures) : Stereoisomers, configurations and symmetry & chirality, enantiomers, diastereomers, optical activity.

Introduction to reactions involving substitution, addition, elimination, oxidation, reduction. Synthesis of a commonly used drug molecule such as Ibuprofen, Aspirin, Paracetamol, Chloroquine/ doxy cycline etc.

(6) Water Technology (6 lectures) : Impurities in natural water, hardness and alkalinity, Disadvantages of hardness i. e. sludge and scale formation, softening of water using lime-soda, zeolite and ion- exchange method, advantages and limitations of these water softening processes, Desalination of water using Reverse Osmosisand electrodialysis.

Suggested Text Books

1. A Textbook of Engineering Chemistry by Dr. Rajshree Khare, S. K. Kataria and Son's Publisher.
2. Selected topics in Inorganic Chemistry by W. U. Malik, R. D. Madan &G. D. Tuli, S. Chand Publications.
3. Engineering Chemistry by A. Pahari, B. Chauhan, Firewall Media, Infinity Science Press LLC.
4. A Textbook of Engineering Chemistry by S. S. Dara, S. Chand Publications.
5. Applied Chemistry by V. K. Walekar, A. V. Bharati, Tech-Max Publications.
6. Organic Chemistry by R. L. Madan, Mc-Graw Hill Publications.
7. Elementary Organic Spectroscopy, Revised Edition by Y. R. Sharma, S. Chand Publications.
8. Organic Chemistry – Reactions and Reagents by O. P. Agrawal, Goel Publishing House Publications.
9. Engineering Chemistry (NPTEL Web-book), by B. L. Tembe, Kamaluddin and M. S. Krishnan

Reference Books

1. Physical Chemistry, by Robert G. Mortimer, Elsevier Academic Press Publications.
2. Chemistry: Principles and Applications, by M. J. Sienko and R. A. Plane, Mc-Graw Hill Publications.

Semester I / II

Department of Mechanical Engineering

Course Code : CHP151 **Course : Chemistry Lab**

L: 0 Hrs., T: 0 Hrs., P: 3 Hrs., Per week **Total Credits : 1.5**

Laboratory Outcomes

The chemistry laboratory course will consist of experiments illustrating the principles of chemistry relevant to the study of science and engineering.

The students will learn to:

- Estimate the amount of different impurities in water/waste water samples.
- Estimate rate constants of reactions and order of the reaction from concentration of reactants/products as a function of time and to validate adsorption isotherms.
- Measure molecular/system properties such as surface tension, viscosity of aqueous or other industrially important liquids/mixtures etc.
- Synthesize a polymer or drug molecule or nano-material.

List of Experiments for Chemistry Lab

1. Determination of Surface tension of a given liquid/mixture.
2. Determination of Viscosity of a given liquid/mixture.
3. Estimation of total, temporary and permanent hardness present in a given water sample.
4. Estimation of type and extent of alkalinities present in a given water sample.
5. Estimation of Cu and Zn in a brass sample.
6. Study of chemical oscillations or iodine clock reaction and determination of rate constant of the reaction.
7. Estimation of acid value of oil.
8. Estimation of saponification value of oil.
9. Ion Exchange column for removal of hardness.
10. Study of adsorption of acetic acid by charcoal.
11. Synthesis a polymer / drug molecule / nano-material.

Suggested Books/Reference Books

(1) A Textbook on Experiments and Calculations in Engineering Chemistry by S. S. Dara, S. Chand Publications.

(2) Advanced Practical Physical Chemistry by J. B. Yadav, Krishna's Prakashan Media (P) Limited.

(3) Collection of Interesting General Chemistry Experiments, A by A. J. Elias, Universities Press Publications.

(4) College Practical Chemistry by V. K. Ahluwalia, S. Dhingra and A. Gulati, Universities Press Publications.

(5) Advanced Practical Medicinal Chemistry by Ashutosh Kar, New Age International Publisher.

Semester I / II
Department of Mechanical Engineering

Course Code : CST151 **Course : Programming for Problem Solving**

L: 4 Hrs., T: 0 Hrs., P: 0 Hrs., Per week **Total Credits : 4**

Course Outcomes

On successful completion of course student will learn:

1. To formulate simple algorithms for arithmetic and logical problems, translate the algorithms to programs (in C language), test and execute the programs and correct syntax and logical errors.
2. To implement conditional branching, iteration and recursion, to decompose a problem into functions and synthesize a complete program using divide and conquer approach.
3. To use arrays to solve various matrix operation, searching, sorting and pointers, Structures for the formulation of algorithms and programs.
4. To understand basics of file operation and to apply various I / O operations for file handling programming.

UNIT - I : Introduction to Programming

Introduction to components of a computer system (disks, memory, processor, where a program is stored and executed, operating system, compilers etc.)

Idea of Algorithm : Steps to solve logical and numerical problems. Representation of Algorithm: Flowchart / Pseudocode with examples. Arithmetic expressions and precedence

UNIT - II : C Programming Language

Introduction to C language: Keywords, Constant, Variable, Data types, Operators, Types of Statements, Preprocessor Directives, Decision Control Statement-if, if-else, Nested if-else statement, Switch case, Loops and Writing and evaluation of conditionals and consequent branching.

UNIT - III : Arrays and Basic Algorithms

Arrays : 1-D, 2-D, Character arrays and Strings.

Searching, Basic Sorting Algorithms (Bubble, Insertion and Selection), Finding roots of equations, notion of order of complexity through example programs (no formal definition required)

UNIT - IV : Functions and Recursion

User defined and Library Functions, Parameter passing in functions, call by value, Passing arrays to functions: idea of call by reference. Recursion: As a different way of solving problems. Example programs, such as Finding Factorial, Fibonacci series, Ackerman function etc. Quick sort or Merge sort.

UNIT - V : Pointers and Structures

Structures, Defining structures, Array of Structures, Introduction to pointers, Defining pointers, Pointer arithmetic, pointer operators, Use of Pointers in self- referential structures, notion of linked list (no implementation)

UNIT - VI : File handling

Streams in C, Types of Files, File Input/ Output Operations: Modes of file opening, Reading andwriting the file, Closing the files, using fflush().

Text Books

1. Programming in ANSI C : E. Balguruswami McGraw Hill
2. Mastering C: K. R. Venugopal and S. R. Prasad, Tata McGraw Hill

Reference Books

1. Programming with C: Byron Gottfried, Schaums Outline Series.
2. Let Us C: Yashwant Kanetkar, BPB Publication

Semester I / II

Department of Mechanical Engineering

Course Code: CSP151 **Course : Programming for Problem Solving Lab**

L: 0 Hrs., T: 0 Hrs., P: 2 Hrs., Per week **Total Credits : 1**

Course Outcomes

On successful completion of course student will be able to:

1. Understand the fundamentals of C programming and choose the loops and decision making statements to solve and execute the given problem.
2. Implement different Operations on arrays also design functions to solve the given problem using C-programming.
3. Understand pointers, structures, unions and apply them to develop programs. Implement file Operations in C programming for a given application

Semester I / II
Department of Mechanical Engineering

Course Code : IDT151 **Course : Creativity Innovation and Design Thinking**

L:1Hrs., T:0Hrs., P:0Hrs., Per week **Total Credits : 1**

Course Outcomes

C1 : Be familiar with processes and methods of creative problem solving

C2 : Enhance their creative and innovative thinking skills

C3 : Practice thinking creatively and innovative design and development

Detailed Topics

UNIT - I

Introduction : Making a case for creativity, Creative thinking as a skill, Valuing diversity in thinking: Thinking preferences, Creativity styles, Creativity in problem solving

UNIT - II

Pattern Breaking : Thinking differently , Lateral thinking, Mind stimulation: games, brain- twisters and puzzles, Idea-collection processes, Brainstorming/Brainwriting, The SCAMPER methods, Metaphoric thinking, Outrageous thinking , Mapping thoughts, Other (new approaches)

UNIT - III

Using Math and Science, Systematic logical thinking, Using math concepts, Eight- Dimensional (8D) Approach to Ideation: Uniqueness, Dimensionality, Directionality, Consolidation, Segmentation, Modification, Similarity, Experimentation

UNIT - IV

Systematic Inventive Thinking : Systematic inventive thinking: The TRIZ methodology, Decision and Evaluation: Focused thinking framework, Six thinking hats , Ethical considerations

UNIT - V

Design for Innovation : Introduction to design for interaction, nine lessons for innovation, difference in creativity and innovation, Building blocks for innovation

UNIT - VI

Intellectual Property : Introduction to intellectual property: Patents, Copyrights©, Trademarks®, Trade Secret, Unfair Competition.

Reference Books and Text Book

1. Creative Problem Solving for Managers - Tony Proctor - Routledge Taylor & Francis Group
2. 101 Activities for Teaching creativity and Problem Solving - By Arthur B Vangundy - Pfeiffer
3. H. S. Fogler and S.E. LeBlanc, Strategies for Creative Problem Solving, Prentice Hall
4. E. Lumsdaine and M. Lumsdaine, Creative Problem Solving, McGraw Hill,
5. J. Goldenberg and D. Mazursky, Creativity in product innovation. Cambridge University Press, 2002.Course Assignments for internal continuous assessment of 20 Marks (NO T1 and T2)

- Brain teasers (aka Puzzle Busters, to be solved individually)
- Cartoon captions (small teams)
- TRIZ, a systematic ideation method, reading (individual)
- Book readings and discussions (small teams)
- Small teams presentations on innovation: (1) innovative individual, (2) innovative company, (3) innovative movie / game, (4) sustainable innovation, (5) innovation in business, (6) innovation inart, (7) innovation in architecture, (8) innovative nation, (9) innovation in science, and (10) innovation in engineering.
- Large groups hands-on projects
- Eight-dimensional (8D) ideation method examples
- Large teams videos

Semester I / II
Department of Mechanical Engineering

Course Code : INT151 **Course : Workshop / Manufacturing Practices (Theory)**

L:1Hrs., T:0Hrs., P:0Hrs., Per week **Total Credits:1**

Course Outcomes

1. Identify the different manufacturing process commonly employed in Industry along with prevailing safety practices.
2. Identify the various tools and equipments to carry out different manufacturing processes accompanied by the inspection of the work part.

Syllabus

Unit - I : Fundamentals of metal cutting, single point cutting tool, fundamental mechanics of metal cutting, fitting operations, and associated measuring and marking tools

Unit - II : Introduction to pattern making for metal casting, different types of carpentry tools, measuring tools and marking tools, holding devices, different types of carpentry joints.

Unit - III : Smithy and Forging, Forging tools like chisels, hammers, types of furnaces, types of coal, Forming operations, Hot working and Cold working of metals.

Unit - IV : Metal joining Process, mechanics of welding, types of welding, soldering and brazing, types of joints.

Unit - V : Introduction to foundries, Metal Casting, types of sand, Introduction to Molding tools &casting process.

Unit - VI : Introduction to Plastic Injection Molding

Suggested Text Book

1. "Elements of Workshop Technology" Hajra S.K, Choudhury A. K , Roy Nirjhar Vol. I and Vol .II, Media Promoters and Publishers Private Ltd. Mumbai.

Reference Books

1. Kalpakjian S. and Schmid S. “Manufacturing Engineering and Technology”4th Edition, Pearson India Education 2008
2. Roy A. and Lindberg, “Process and Materials of Manufacture”4th Edition, Prentice Hall India1998.

Semester I / II
Department of Mechanical Engineering

Course Code : INP151 **Course : Workshop/Manufacturing Practices Lab (Practical)**

L:0Hrs.,T:0Hrs.,P:2Hrs.,Per week **Total Credits : 1**

Laboratory Outcomes

On the completion of the course the students shall be able to;

1. Recognize the different manufacturing process commonly employed in the Industry
2. Make the components using required manufacturing process, inspection methods while practicing the requisite safety precautions

Contents

1. Fitting Practice
2. Welding and Soldering Practice
3. Pattern Making Practice
4. Metal Casting Practice
5. Smithy and Forging Practice
6. Machining Practice
7. Plastic Molding Process
8. Glass Cutting

Suggested Text Book

1. "Elements of Workshop Technology'" Hajra S. K, Choudhury A. K , Roy Nirjhar Vol. I and Vol .II, Media Promoters and Publishers Private Ltd Mumbai.

Reference Books

1. Kalpak Jain S. and Schmid S. "Manufacturing Engineering and Technology"4th Edition, PearsonIndia Education 2008
2. Roy A. and Lindberg, "Process and Materials of Manufacture", Prentice hall India 1998.

Semester I / II
Department of Mechanical Engineering

Course Code : HUT151 **Course : English**

L: 2 Hrs. T: 0 Hrs. P: 0 Hrs. Per week **Total Credits : 2**

Course Objectives

The main objective of the subject is to enhance the employability skills of engineering students as well as communication skills at work place. The sub-objectives are:

1. To develop vocabulary of students.
2. To orient students in basic writing skills.
3. To orient students in functional grammar.
4. To orient students in the process of effective writing.
5. To provide practice and improve students' oral communication skills.

Course Outcomes

1. Students will have good word power.
2. Students will acquire basic writing skills.
3. Students will understand functional grammar and its usage.
4. Students will organize and express their thoughts effectively through written communication.
5. Students will learn oral communication skills in order to handle themselves effectively in an interview and group discussion

SYLLABUS

1. Vocabulary Building

The concept of Word Formation

Root words from foreign languages and their use in English

Acquaintance with prefixes and suffixes from foreign languages in English to form derivatives Synonyms, Antonyms and standard abbreviations

2. Basic Writing Skills

Sentence Structures

Use of phrases and clauses in sentences Importance of proper punctuation Creating coherence

Organizing principles of paragraphs in documents

Techniques for writing precisely

3. Identifying Common Errors in Writing 3.1 Subject-verb agreement

Noun-pronoun agreement Misplaced modifiers Articles

Redundancies Cliches

4. Nature and Style of sensible Writing 4.1 Describing

Defining

Classifying4.4Providing examples or evidence

5. Writing Practices Comprehension Precis Writing

Essay Writing Letter Writing Email Writing

6. Oral Communication

(This unit involves interactive practice sessions in Language Lab)

- Listening Comprehension
- Pronunciation, Intonation, Stress and Rhythm
- Common Everyday Situations : Conversations and Dialogues
- Communication at Workplace
- Interviews
- Formal Presentations

Books

1. Communication Skills. Sanjay Kumar and PushpLata. Oxford University Press. 2011.
2. Practical English Usage. Michael Swan. OUP. 1995.
3. Remedial English Grammar. F.T. Wood. Macmillan.2007
4. On Writing Well. William Zinsser. Harper Resource Book. 2001
5. Study Writing. Liz Hamp-Lyons and Ben Heasly. Cambridge University Press. 2006.
6. Exercises in Spoken English. Parts. I-III. CIEFL, Hyderabad. Oxford University Press

Semester I / II
Department of Mechanical Engineering

Course Code : HUP151 **Course : English Lab**

L: 0 Hrs. T: 0 Hrs. P: 2 Hrs. Per week **Total Credits : 1**

Course Objective

The main objective of the subject is to enhance the employability skills of engineering students as well as communication skills at work place. The sub-objectives are:

1. To orient students in the process of effective writing.
2. To provide practice and improve students' oral communication skills.

Course Outcomes

1. Students learn presentation and public speaking skills
2. Students learn to practice effective strategies for Personal Interview and Group Discussions
3. Students learn and effectively apply language skills – listening, speaking, reading and writing

List of Practical (2 hours each for each batch) based on unit 6 (oral communication).

1. Common Everyday Situations: Conversations and Dialogues
2. Pronunciation, Intonation , Stress, and Rhythm
3. Formal Presentations: Orientation
4. Formal Presentations : Practice Session
5. Interviews: Orientation
6. Interviews: Practice Session
7. Communication at Workplace: Group Discussion- Orientation
8. Communication at Workplace: Practice Session

III Semester
Department of Mechanical Engineering

Course Code : MET251 | **Course : Materials Engineering**

L: 3 Hrs. T: 0 Hrs. P: 0 Hrs. Per week | **Total Credits : 03**

Course Objectives

This course provides students an understanding of basic structure of materials, ferrous and non ferrous metals and alloys, heat transfer processes, composites, polymers, ceramics, power metallurgy and smart materials.

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Understand the fundamentals of various engineering materials and their crystal structure.
2. Compute the mechanical properties of engineering materials using various testing methods
3. Interpret and explain the phase diagram and make use of this knowledge to illustrate the Iron-Iron carbide equilibrium diagram.
4. Realize the significance and general procedure of heat treatment processes.
5. Understand the composition, microstructure, properties and application of alloy steels, cast-iron and non metal alloys.
6. Understand composite material, ceramics, polymers and powder metallurgy.

Syllabus

Unit I:

Classification and properties of engineering materials.

Structure of materials: crystal structure – grouping of atoms, binding in solids, space lattice and unit cell, indexing of lattice planes and directions, atomic packing factor. Mechanism of crystallization, polymorphism.

Imperfection in crystals: Point, line, interfacial and volume defects.

Dislocations, strengthening mechanisms and slip systems, critically resolved shear stress. (8)

Unit II:

Mechanical Property measurement: Tensile, compression and torsion tests; Young's modulus, relations between true and engineering stress-strain curves, generalized Hooke's law, yielding and yield strength, ductility, resilience, toughness and elastic recovery. Hardness test : Rockwell, Brinell and Vickers tests and their relation to strength. Impact tests: Izod and Charpy.

Fracture with fatigue, Fatigue test, S-N curve, creep test. Introduction to nondestructive testing (NDT) (8)

Unit III:

Alloys, solid solutions, compounds, Hume-Rothery's rules of solid solubility, Gib's phase rule.

Solidification of pure metal, critical size of nucleus, shape of crystals, dendritic growth. Types of

cooling curves, non equilibrium cooling.

Phase diagrams: Interpretation of binary phase diagrams and microstructure development; eutectic, peritectic, peritectoid and monotectic reactions. (6)

Unit IV:

Solidification of pure iron, Iron Iron-carbide phase diagram and microstrctural aspects of austenite, ferrite and cementite, pearlite and ledeburite. Critical temperatures, invariant reactions.

Solidification and transformation of steel and cast-iron.

Classification of steel, Heat treatment of Steel, Isothermal transformation (TTT) diagrams for Fe-C alloys and microstructure development. Continuous cooling curves (CCT) and interpretation of final microstructures and properties.

Annealing, tempering, normalizing and hardening. Austempering, martempering, case hardening, carburizing, nitriding, cyaniding, carbo-nitriding, flame and induction hardening, vacuum and plasma hardening. (8)

Unit V:

Alloying of steel, properties of stainless steel and tool steels, maraging steels. Cast irons; grey, white, malleable and spheroidal cast irons.

Copper and copper alloys; brass, bronze and cupro-nickel. Bearing Materials. Aluminium and Al-Cu – Mg alloys, Nickel based super alloys and Titanium alloys. (8)

Unit VI:

Introduction to composite materials, Ceramics, Polymers. Introduction to Powder metallurgy, smart materials. (7)

Text Books

1. V. D. Kodgire & S. V. Kodgire, Material Science and Metallurgy for Engineers, Everest Publishing House.
2. Sindney H Avner , Introduction to Physical Metallurgy, Mc-Graw Hill Education (India) Pvt. Ltd.
3. L. Krishna Reddy, Principles of Engineering metallurgy , New Age International Publishers

Reference Books:

1. W. D. Callister, 2006, “Materials Science and Engineering-An Introduction”, 6th Edition, Wiley India.
2. Kenneth G. Budinski and Michael K. Budinski, “Engineering Materials”, Prentice Hall of India Private Limited, 4th Indian Reprint, 2002.
3. V. Raghavan, “Material Science and Engineering', Prentice Hall of India Private Limited,1999.
4. U. C. Jindal, “Engineering Materials and Metallurgy”, Pearson, 2011.

III Semester
Department of Mechanical Engineering

Course Code : MEP251 **Course : Materials Engineering**

L: 0 Hrs. T: 0 Hrs. P: 01 Hrs. Per week **Total Credits : 0.5**

Course Objectives

This course provides students hands on practice on tensile test, hardness test, impact test, microscopic examination of metals and alloys, heat treatment processes.

Course Outcomes

1. Ability to identify phases and composition of various alloys by metallographic examination using metallurgical microscope.
2. Ability to get hands on experience on various heat treatment processes.
3. Ability to measure hardness and toughness of engineering materials.
4. Ability to understand working, principle and utilization of UTM to derive various material properties.

The laboratory will have minimum Ten Practical based on the syllabus of MET251

1. To study the Metallurgical Microscopes
2. Preparation of specimen for metallo graphic examination.
3. Micro-structural examination of different types of Steels.
4. Micro-structural study of White Cast Iron and Grey Cast Iron.
5. Micro-structural study of Malleable Cast Iron and Nodular Cast Iron.
6. To study the effect of normalizing on properties of steel.
7. To study the effect of annealing on properties of steel.
8. Measurement of hardness with the help of Rockwell Hardness Tester.
9. Measurement of hardness with the help of Brinell Hardness Tester.
10. Determination of tensile properties of ductile material.
11. Determination of impact properties by Izod /Charpy test.
12. Effect of hardening process on properties of steels.

III Semester
Department of Mechanical Engineering

Course Code : MEP252 **Course : M/C Drawing & Solid Modeling**

L: 0 Hrs. T: 0 Hrs. P: 02 Hrs. Per week **Total Credits : 01**

Course Objectives

1. To develop an ability to construct assembly and disability of machine and its components considering limits, fits and dimensioned tolerances as idell of geometric toleranced to components and assemblies on Engineering Drawings.
2. To develop an ability to create solid models of machine component and assembly.

Course Outcomes

1. Ability to select standard machine elements as per the standards.
2. Ability to draw and read production drawings.
3. Ability to use the Drafting and Design package e.g. Catia V6.
4. Ability to model machine components using geometric modeling software and able to construct detailed draft views of part or assembly

Syllabus

UNIT 1:

Conventional representations of standard machine elements like: Bolts, Nuts, Washers, Rivets, and Keys & Couplings. Selection of standard machine elements. Thread terminology, Types of Threads & their representations. Machining Symbols.

UNIT 2:

Limits: Terminology Fits: Types & Applications of fits. Dimensional Tolerance, Geometrical Tolerance. Tolerance Grades & Tolerance Charts, calculations of dimensional tolerance.

UNIT 3:

Assembly and Dismantling Principles: Study of some Standard Assemblies. Subassembly Drawing, Full Assembly Drawing, Exploded Views. Preparation of Bill of material. Production drawing preparation.

UNIT 4: Part modeling and assembly

Module-1 Introduction to modeling and basic concepts , Using solid modeling software interface Selecting and Editing, Sketcher geometry. Creating datum Features: Planes and Axes.

UNIT 5:

Creating datum Features: Planes and Axes , Creating extrudes, Revolves and Ribs ,Creating sweeps and blends (geometric features),Creating holes, shells and drafts, Creating rounds, chamfers ,Copy and mirror tools (Editing features)),Creating patterns. Module -2 Assembling with constraints, exploding assemblies

UNIT 6:

Detailing of Drawings, Introduction to drawings, Creating new drawings and views, Adding details to drawings, Adding notes to drawings, Adding tolerance and symbols

Text Books

1. Machine Drawing by N. D. Bhat, Charotar Publications
2. Machine Drawing by K.L.Narayan, R. Kannaiah, K.V.Reddy, New Age Int. Publishers

Reference Books

1. Machine Drawing by R. K. Dhawan, S. Chand Publications
2. Machine Drawing by P. S. Gill, S. K. Kataria & Sons
3. Engineering Drawing Practice for Schools & Colleges (SP-46:1988): Bureau of Indian Standards.
4. SP46 : 2003, Indian Standards.

III Semester
Department of Mechanical Engineering

Course Code : MET253 **Course : Engineering Mechanics**

L: 3 Hrs. T: 0 Hrs. P: 0 Hrs. Per week **Total Credits : 03**

Course Objectives

1. The primary purpose of the study of Engineering mechanics is to develop the capacity to predict the effects of force and motion while carrying out the creative design functions of engineering.
2. This capacity requires the ability to visualize physical configurations in terms of real materials, actual constraints of and the practical limitations which govern the behaviour of mechanics and structures.

Course Outcomes

After Completion of the syllabus, the students should be able to :

1. Define and describe various terms related with static and dynamic behaviour of rigid bodies.
2. Understand, describe and analyse the problems of statics with the help of Free Body Diagram and related theories.
3. Understand, describe and analyse the problems of dynamics with the help of Free Body Diagram and related theories.

Unit 1:

Introduction to Engineering Mechanics covering, Force Systems, Basic concepts, Particle equilibrium in 2-D & 3-D; Rigid Body equilibrium; System of Forces, Coplanar Concurrent Forces, Components in Space – Resultant- Moment of Forces and its Application; Couples and Resultant of Force System, Equilibrium of System of Forces, Free body diagrams, Equations of Equilibrium of Coplanar Systems and Spatial Systems; Static Indeterminacy.

Unit 2:

Friction covering, Types of friction, Limiting friction, Laws of Friction, Static and Dynamic Friction; Motion of Bodies, wedge friction.

Unit 3:

Centroid and Centre of Gravity covering, Centroid of simple figures from first principle, centroid of composite sections; Centre of Gravity and its implications; Area moment of inertia- Definition, Moment of inertia of plane sections from first principles, Theorems of moment of inertia, Moment of inertia of standard sections and composite sections; Mass moment inertia.

Unit 4:

Virtual Work and Energy Method- Virtual displacements, principle of virtual work for particle and ideal system of rigid bodies, degrees of freedom.

Unit 5:

Review of particle dynamics - Kinetics of Particles - Forces & Acceleration, Work- energy, Impulse-momentum (linear, angular); Impact (Direct and oblique).

Unit 6:

Introduction to Kinetics of Rigid Bodies ; Kinetics of rigid body rotation, Circular motion of rigid bodies, Kinetics of rolling bodies.

Text Books

1. Bansal R.K.(2010), A Text Book of Engineering Mechanics, Laxmi Publications
2. S.S. Bhavikatti (2017), Engineering Mechanics, New Age Publications
3. A.K. Sharma, Fundamental of Engineering Mechanics, Sai Publications

Reference Books

1. Irving H. Shames, Engineering Mechanics – Statics and Dynamics, Pearson Educations, Forth edition, 2003.
2. Beer and Johnston, Vector Mechanics for Engineers, Vol.1 “Statics” and Vol.2 “Dynamics, McGraw Hill International Edition, 1995.
3. Suhas Nitsure, Engineering Mechanics, Technical Publications, Pune, 2007.
4. R. C. Hibbler (2006), Engineering Mechanics: Principles of Statics and Dynamics, Pearson Press.
5. S.S. Deo, (2017), Engineering Mechanics, Nirali Publications.

III Semester
Department of Mechanical Engineering

Course Code : MET254 **Course : Manufacturing Processes**

L: 3 Hrs. T: 0 Hrs. P: 0 Hrs. Per week **Total Credits : 03**

Course Outcomes

The objective of the course is :

1. To familiarize and get acquainted with major manufacturing process and required Machine Tools.

2. To identify, discuss and select the appropriate process, associated machine and equipment for manufacturing required product.

Course Outcomes

The expected learning outcome is that the students will be able to :

1. Select a suitable pattern and casting method for manufacturing casted components.
2. Select a suitable hot / cold working method to manufacture metal components.
3. Select a suitable joining processes for fabrication work of ferrous and non ferrous metals.
4. Identify the machining parameters, cutting tool materials and cutting fluids for different machining operations.
5. Understand concept of rapid prototyping its types, their working principle and applications.
6. Distinguish and select appropriate unconventional machining process for manufacturing complex shape component.

Syllabus

Unit - I

Casting and moulding : Metal casting processes and equipment, Heat transfer and Solidification, shrinkage, riser design, casting defects and residual stresses. (7)

Unit - II

Forming Processes : Introduction to bulk and sheet metal forming, plastic deformation and yield criteria, fundamentals of hot and cold working processes, load estimation for bulk forming (forging, rolling, extrusion, drawing) and sheet forming (shearing, deep drawing bending) principles of powder metallurgy. (5)

Unit - III

Joining / Fastening Processes : Physics of welding, brazing and soldering, design consideration in welding, Solid and liquid state joining processes, Adhesive bonding. (5)

Unit - IV

Metal Cutting : Single and multi-point cutting : Orthogonal cutting, various force components, chip formation, Tool wear and tool life, Surface finish and integrity, Machinability, Cutting tool materials, Cutting fluids, machining operations : Turning, Drilling, Milling, Introduction to CNC machine. (10)

Unit - V

Additive Manufacturing : Overview, basic principle and advantages, procedure of product development, classification of additive manufacturing and manufacturing processes. (5)

Unit - VI

Unconventional Machine Processes : Characteristics, operation, applications, limitations and selection of processes parameters of Abrasive Jet Machining, Ultrasonic Machining, EDM, ECM, Laser Beam Machining (LBM), Plasma Arc Machining (PAM) and Electron Beam Machining. (8)

Text Books

1. Manufacturing Technology, Volume - I & II - P.N. Rao, Tata McGraw Hill Pub. Company, New Delhi.
2. Manufacturing Science - A. Ghosh & A. K. Malik - East West Press Pvt. Ltd. New Delhi.
3. Workshop Technology, Volume - I & II - By Hajra Choudhary, Media Promoters & Publishers Pvt. Ltd.

Reference Books

1. Kalpakjian and Schmid, Manufacturing processes for engineering materials, 5th Edition - Pearson India, 2014.
2. Mikell P. Groover, Fundamentals of Modern Manufacturing : Materials, Processes, and System.
3. Production Engineering - P. C. Sharma, S. Chand and Company Ltd., New Delhi.

III Semester
Department of Mechanical Engineering

Course Code : MEP254 **Course : Manufacturing Processes**

L: 0 Hrs. T: 0 Hrs. P: 2 Hrs. Per week **Total Credits : 01**

Course Objectives

The Objective of the course is :

1. To familiarize with major manufacturing process and required Machine Tools.
2. To get acquainted with and hands on experience on machine tools and equipments.

Course Outcomes

The expected learning outcome is that the students will be able to :

1. Perform different operations on lathe, shaper, milling and drilling machine.
2. Understand the basic components and working of CNC machines.
3. Understand working principle of unconventional machining process like EDM.
4. Prepare a casting using sand mould and identify various casting defects.

List of Experiments

About 10 experiments will be carried out from :

1. Taper turning and external thread cutting using lathe.
2. Contour milling using milling machine.
3. Spur gear cutting in milling machine.
4. Measurement of cutting forces in Turning process.
5. Precision drilling on radial Drilling Machine.
6. To perform various operations on Shaper Machine.
7. CNC : Demonstration and part programming.
8. EDM - Demonstration.
9. To study different types of melting furnaces.
10. To carry out moulding and casting using pit furnace for different patterns.
11. Study of various casting defects & observations of the actual casting.
12. 3D printing : Demonstration.
13. To study constructional details and working of Power Press.

III Semester
Department of Mechanical Engineering

Course Code : MAT257 **Course : Engineering Mathematics**

L: 3 Hrs. T: 1 Hrs. P: 0 Hrs. Per week **Total Credits : 04**

Course Objectives

1. To develop logical understanding of the subject.
2. To develop mathematical skill so that students are able to apply methods and principles in solving problem from engineering fields.
3. To make aware students about the importance and symbiosis between Mathematics and Engineering.

Course Outcomes

After studying the course, the student will be able to:

1. Solve field problems in engineering involving PDEs.
2. Formulate and solve problems involving random variables
3. Apply statistical methods for analyzing experimental data
4. Understand complex variable.

Syllabus

MODULE I: (17Hrs) :

Definition of Partial Differential Equations, First order partial differential equations, solutions of first order linear PDEs; Solution to homogenous and non-homogenous linear partial differential equations of second order by complimentary function and particular integral method. Second-order linear equations and their classification, Initial and boundary conditions, D'Alembert's solution of the wave equation; Heat diffusion and vibration problems, Separation of variables method to simple problems in Cartesian coordinates. One dimensional diffusion equation and its solution by separation of variables.

MODULE II: (13Hrs) :

Discrete random variables, Independent random variables, the multinomial distribution, Poisson approximation to the binomial distribution, infinite sequences of Bernoulli trials, sums of independent random variables; Expectation of Discrete Random Variables, Moments, Variance of a sum, Correlation coefficient, Chebyshev's Inequality. Continuous random variables and their properties, distribution functions and densities, normal, exponential and gamma densities. Bivariate distributions and their properties, distribution of sums and quotients, conditional densities.

MODULE III: (12Hrs) :

Basic Statistics, Measures of Central tendency: Moments, skewness and Kurtosis -

Probability distributions: Binomial, Poisson and Normal - evaluation of statistical parameters for these three distributions. Test of significance: Large sample test for single proportion, difference of proportions, Tests for single mean, difference of means, and difference of standard deviations. Test for ratio of variances - Chi-square test for goodness of fit and independence of attributes.

MODULE IV(8Hrs) :

Differentiation, Cauchy-Riemann equations, analytic functions, harmonic functions, finding harmonic conjugate; elementary analytic functions Contour integrals, Cauchy Integral formula (Without proof), Taylor's series, zeros of analytic functions, singularities; Residues, Cauchy Residue theorem (without proof).

Text Book

1. B. S. Grewal, Higher Engineering Mathematics, Khanna publishwers 43rd edition (2015)

Reference Books

1. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
2. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.
3. P. G. Hoel, S. C. Port and C. J. Stone, Introduction to Probability Theory, Universal Book Stall, 2003 (Reprint).
4. S. Ross, A First Course in Probability, 6th Ed., Pearson Education India, 2002.

III Semester
Department of Mechanical Engineering

Course Code : IDT251 **Course : Biology**

L: 2 Hrs. T: 0 Hrs. P: 0 Hrs. Per week **Total Credits : 02**

Course Objectives

1. To understand building blocks of biology with engineering perspective.
2. To develop the ability to correlate biological tissue parameters with Mechanical Systems.

Course Outcomes

The expected learning outcome is that the students will be able to :

After studying the course, the student will be able to :

1. Understand Engineering perspective of Biology.
2. Convey that life has the same building blocks and yet the manifestation differs.
3. Analyze genetic code, DNA cloning and disorders.
4. Understand the fundamentals of biomechanics.
5. Formulate engineering models of Human Body.
6. Understand computational biomechanics.

Syllabus

Unit - II

Introduction : Engineering perspective of Biological Sciences, Fundamental differences between science and Engineering - case studies, Hierachy and classification of life forms, Levels of organization of life - cell, tissues, organs, system and organism, Anatomy and physiology.

Unit - II

Biomolecules and Enzymes : Biomolecules as basic building block of all forms of life, structure and function of carbohydrates, proteins and Amino acids, Lipids, Nucleic acids, Vitamins and Minerals, Enzymology - Introduction, classification and mechanism of action.

Unit - III

Genetics : Introduction to Genetics, genetic codes, Expression and Transmission of genetic Information, concept of DNA cloning, single gene disorders in humans.

Unit - IV

Introduction to Biomechanics of human body. Fundamentals of Biomechanics and qualitative analysis. Musculo-skeletal systems. Biological materials Bone, cartilage, ligament, tendon, Muscles, their physical properties.

Unit - V

Human Body Models for Analysis : Lumped mass, multi body, FE and integrated models, modeling of contact, modeling of muscles.

Unit - VI

Mechanobiology and its applications : Principles of Diagnostic tools and instrumentation, Digital data processing, General considerations of modeling and analysis. Computational Biomechanics. Tissue material models. Case studies in Biomechanical clinical research.

Text Books

1. Biology : A global approach : Campbell, N. A. Reece, J. B. Urry, Lisa, Cain, M. L. Wasserman, S. A. Minorsky, P. V.Jackson, R. B. Pearson Education Ltd.
2. Duane Knudson, Fundamentals of Biomechanics 2nd edition, Springer.

Reference Books

1. Outlines of Biochemistry, Conn, E. E. Stumpf, P. K. Bruening, G, Doi, R. H. John Wiley and Sons.
2. Molecular Genetics, 2nd Edition, Stent, G. S. and Calendar, R. W. H. Freeman and company, Distributed by Satish Kumar Jain for CBS Publisher.
3. Nigg, B. M. and Herzog, W. "Biomechanics of Muysculo skelton system", John Wiley and sons, 1st Edition.
4. Winter D. "Biomechanics and Motor Control of Human Movement", Wiley Interscience 2nd Edition.
5. Vishal Shukla, Engineering Perspectives in Renal Artery Stenosis and Stenting , Sara Book Publications, India, ISBN - 978 - 1-63040-149-8.

III Semester
Department of Mechanical Engineering

Course Code : MEP260 **Course : Industrial Visit**

L: 0 Hrs. T: 0 Hrs. P: 02 Hrs. Per week **Total Credits : 00**

Course Objectives

1. To provide students an insight regarding internal working of companies.
2. To provide an opportunity to learn practically through interaction, working methods and employment practices.

Course Outcomes

1. Co-relate the theoretical knowledge with its practical implementation.
2. Understand the various manufacturing processes studying in their curriculum.
3. Familiarization with various mechanical components/elements such as Boiler, Turbine, Gears, Bearings, and different manufacturing domains etc.
4. Ability to understand the working of industry like plant layout, material handling, dispatch, sells, marketing, and safety criteria.

Syllabus

Students should be taken for visit to Industries. Visits to minimum two different types of industries are expected. Students should submit a visit report in the format given below after the visit. Preferably they should make a presentation.

Report should consist of –

1. Name of industry.
2. Nature of ownership.
3. Year of establishment.
4. List of finished products.
5. Annual turnover of company.
6. Number of employees.
7. List of departments.
8. Classification of Industry.

a. Based on turnover.

b. Based on product / process.

9. List of major machines / equipments.
10. List of raw material used.

IV Semester
Department of Mechanical Engineering

Course Code : MET261 **Course : Kinematics and Dynamics of Machinery**

L: 3 Hrs. T: 1 Hrs. P: 0 Hrs. Per week **Total Credits : 04**

Course Objectives

Students shall be able to :

To cover the kinematics and dynamic of planar single degree of freedom systems, to develop skills for designing and analysing linkage, cams, gears and other mechanism and to provide a foundation for the study of Machine Design Course.

Course Outcomes

1. Understand the kinematics and rigid- body dynamics of kinematically driven machine components
2. Understand the motion of linked mechanisms in terms of the displacement, velocity and acceleration at any point in a rigid link
3. Classify and synthesize the cams for different follower motions
4. Demonstrate the understanding of successfully addressing issues related to kinematics of Spur gears and gear trains
5. Examine the balancing of the rotating and reciprocating elements to avoid the failure and analyze the free and forced vibrations in SDOF systems
6. Demonstrate the gyroscopic effect on airplane, ship, four wheeler, two wheeler and Exhibit skills towards application of dynamic force analysis

Syllabus

Unit-I:

Basics of Mechanisms and Machines

Basic concept of mechanism, link, kinematics pairs, kinematics chain, mechanism, machine, simple & compound chain, Degree of freedom, Kutzbach's theory, Grubber's criterion. Harding's notations, Class-I & Class-II mechanisms, Inversions of four bar chain and slider crank chains, Limit positions- Mechanical advantage- Transmission angle, various types of mechanism such as Geneva wheel, Pawl and ratchet mechanism. (8)

Unit-II:

kinematic analysis of Mechanisms

Displacement, velocity and acceleration analysis of simple mechanisms, graphical velocity analysis using instantaneous centers, velocity and acceleration analysis using loop closure equations- kinematic analysis of simple mechanisms- slider crank mechanism coincident points- Coriolis

component of acceleration (8)

Unit-III:

Cams and Followers

Classification of cams and followers- Terminology and definitions- Displacement diagrams-uniform velocity, parabolic, simple harmonic and cycloidal motions- derivatives of follower motions- pressure angle and undercutting, Introduction to linkage synthesis three position graphical synthesis for motion and path generation (8)

Unit-IV:

Kinematics of Gear and Gear Trains

Involute and cycloidal gear tooth profiles, gear terminologies, fundamental law of gearing and conjugate action, spur gear, length of path of contact, length of arc of contact, contact ratio and interference/undercutting.

kinematics of regular and epicyclic gear trains (8)

Unit-V:

Balancing of Masses

Inertia forces and their balancing for rotating and reciprocating machines. Balancing of Inline engines, radial engines, Free and forced vibration of SDOF system, whirling speed of shaft, Introduction to 2 DOF systems, vibration absorbers (9)

Unit-VI:

Gyroscopic Motion and Static Force Analysis

Rigid body motion in space, Euler's equation of motion, simple precession and gyroscopic couple, Gyroscopic effect on airplane, ship, vehicles and grinding mills, Dynamic force analysis of planar linkages such as four bar chain and reciprocating mechanism by graphical method (9)

Text Books

1. Theory of Machines: S.S. Rattan, Tata McGraw Hill Publishers, 3rd edition onwards

Reference Books

1. Kinematics & Dynamics of Machinery: R. L. Norton Tata McGraw Hill Publishers
2. Mechanism and Machine Theory: J. S. Rao & Rao V. Dukkipati, New Age International
3. Theory of Mechanisms and Machines: Ghosh& Mallik, Tata McGraw Hill
4. Theory of Machines: Thoman Bevan, CBS publication
5. Theory of Machines and Mechanisms: Uicker and Shigley, Tata McGraw Hill

IV Semester
Department of Mechanical Engineering

Course Code : MEP261 **Course : Kinematics and Dynamics of Machinery**

L: 0 Hrs. T: 0 Hrs. P: 2 Hrs. Per week **Total Credits : 01**

Course Objectives

To exemplify the concepts of gyroswpic effects, static and dynamic man balancing and to teach linear vibration analysis of one and two degree of freedom rigid body system.

Course Outcomes

Students shall be able to

1. Demonstrate the importance of gyroscopic couple and balancing of rotary and reciprocating machine components.
2. Determine the frequency of Longitudinal, Transverse and Torsional vibrations.
3. Understand the effects of jumping phenomenon in cams and whirling speed of a shaft
4. Understand and examine the balancing of the rotating and reciprocating elements to avoid the failure.

Objectives of this lab are to impart practical knowledge on design and analysis of mechanisms for the specified type of motion in a machine. With the study of rigid bodies motions and forces for the transmission systems, machine kinematics and dynamics can be well understood.

Mechanisms form the basis of any machine and it is an assemblage of rigid bodies so that they move upon each other with definite relative motion.

Demonstration exercises are provided with wide varieties of transmission element models to understand machine kinematics. Various experiments with gyroscopes, balancing machines, cam dynamics, governors, whirling of shaft and vibrations of a spring mass system are available to understand machine dynamics.

List of Practicals

1. Simple and Compound Pendulum
2. Bi-filar Suspension
3. Motorized Gyroscope
4. Cam Dynamics
5. Whirling of Shaft
6. Balancing of Rotary Masses
7. Balancing of a Single Reciprocating Mass
8. Natural Vibrations of a spring mass system
9. Free Vibrations of an equivalent spring mass system
10. Forced Vibrations of an equivalent spring mass system
11. Free Torsional vibrations of single rotor system
12. Free Torsional vibrations of two rotor system

IV Semester
Department of Mechanical Engineering

Course Code : MET262 **Course : Thermodynamics**

L: 3 Hrs. T: 1 Hrs. P: 0 Hrs. Per week **Total Credits : 04**

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Understand Engineering approach of thermodynamics and identify processes and compute associated heat and work transfer.
2. Learn balance of energy between system and its surroundings and apply laws of thermodynamics to thermal utilities.
3. Understand the concept of Heat engine, Refrigerator & Heat Pumps.
4. Understand the II law limitations on energy conversion and concept of entropy.
5. Analyze steam power cycles and thermodynamic relations.
6. Evaluate the changes in properties of substances in various processes.

Syllabus

UNIT 1

Fundamentals-Approaches of Thermodynamics, System & Control volume, Concept of Continuum, Property of system ,State Postulate, State and Equilibrium, Process, Path and Cycle; Forms of Energy, Concept of total energy E, Work-Thermodynamic definition of work; examples on Displacement work; Path dependence of displacement work and illustrations for simple processes: electrical, magnetic, gravitational, spring and shaft work, Temperature, Definition of thermal equilibrium and Zeroth law, Temperature scales and various Thermometers Definition of heat; examples of heat/work interaction in systems, Exact & Inexact differentials.(8)

UNIT2

Joules Experiment and Introduction to First Law, First Law applied to closed systems, Energy as a property; Internal Energy and Joule Law, Specific heat and Enthalpy. First Law applied to Open Systems, Derivation of general energy equation for open systems; Steady state steady flow processes including throttling and examples of steady flow devices. (8)

UNIT3

Limitations of First Law, Thermal Energy Reservoir, Heat Engines, Refrigerator and Heat Pumps, Definitions of thermal efficiency and COP, Kelvin-Planck and Clausius statements, Definition of reversible process; Internal and external irreversibility; Carnot cycle; Absolute temperature scale.(8)

UNIT4

Clausius inequality, Definition of entropy, Entropy as a property; Evaluation of Entropy for solids, liquids, ideal gases undergoing various processes; Determination of Entropy from steam tables- Principle of increase of entropy, Illustration of processes on Ts coordinates. Definition of Isentropic efficiency for compressors, turbines and nozzles (10)

UNIT5

Irreversibility and Availability, Availability Function for Systems and Control volumes undergoing different processes, Thermodynamic Relations, Maxwel Equation, Clausius- Clapeyron Equation.Thermodynamic cycles - Basic Rankine cycle; Basic Brayton cycle; Basic vapor compression cycle and comparison with Carnot cycle, Otto cycle & diesel cycle. (8)

UNIT 6

Definition of Pure substance, Ideal Gases and ideal gas mixtures, Real gases and real gas mixtures, Compressibility charts- Properties of two phase systems - Const. temperature and Const. pressure heating of water; Definitions of saturated states; P-v-T surface; Use of steam tables and R134a tables; Saturation tables; Superheated tables; Identification of states & determination of properties, Mollier's chart. (8)

Text Books

1. Engineering Thermodynamics: P. K. Nag, Tata Mc-Graw Hill publication
2. Thermal Engineering: R.K. Rajput, Laxmi publications.

Reference Books

1. Thermodynamics - An Engineering approach: Yunus A. Cengel, Michael A. Boles, Mc-Graw Hill publication
2. Thermal Engineering: P.L. Balaney, Khanna Publisher.

IV Semester
Department of Mechanical Engineering

Course Code : MET263 | **Course : Strength of Materials**

L: 3 Hrs. T: 1 Hrs. P: 0 Hrs. Per week | **Total Credits : 04**

Course Objectives

This course provides students an understanding of basic concept of simple and complex stress, strain and analysis of tensile, compressive, shear, torsional, bending hoop stresses.

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Understand basic concept of stress, strain and their relations based on linear elasticity, material behavior due to different types of loading.
2. Learn analytical and graphical analysis of compound stresses and analysis of strain energy.
3. Develop shear force – bending moment diagram of beams under different loading conditions & support conditions and analyze bending & shear stresses in beams.
4. Analyze torsional shear stresses in circular shafts.
5. Analyze deflection of beams, columns & struts.
6. Analyze stresses in cylinders, spherical shells and rotating discs.

Syllabus

Unit- I:

Concept of simple stresses and strains: Deformation in solids- Hooke's law, stress and strain diagram, tension, compression and shear stresses, saint-venant's principle; poisson's ratio; volumetric, linear, and shear strains; principle of superposition, statically indeterminate systems, compound bars; elastic constants and their relations; Factor of safety (8)

Thermal stresses and strain. (2)

Unit- II:

Compound stresses and strain: normal and shear stress on inclined plane, principal stresses and principal planes, maximum shear stresses, Mohr's circle.

Normal and shear strain, principal strain, principal shear strain, strain rossets, determination of principal stresses from principal strains. (5)

Strain energy: Strain energy stored in a body when subjected to axial loading, & impact loading, strain energy in three dimensional system. (3)

Unit –III:

Shear force and bending moment: Relation between load, shear force and bending moment, Shear force and bending moment diagrams for different types of beams subjected to different types of loads.(5)

Bending and shear stresses in beams:

Theory of simple bending, bending equation, section modulus, bending stresses in symmetrical and unsymmetrical sections, composite beams, beam of uniform strength.

Shear stress equation, shear stresses across standard sections and built up sections. Compound stresses in beam. (5)

Unit –IV:

Torsion of circular shafts: Derivation of torsion equation, Strength and rigidity criterion for design of shaft; torque transmitted by solid and hollow shafts; stepped shafts, composite shafts, tapering shafts. Comparison of solid and hollow shafts; Compound stresses in shaft, Derivation of principal stresses and maximum shear stress induced in shaft subjected to bending moment, torque & axial load, Torsional strain energy.(8)

Unit –V:

Deflection of beams: - Derivation of differential equation of elastic curve. Relation between slope, deflection & radius of curvature. Double integration method, Macaulay's method, area moment method to determine deflection of beam. Castingliano's theorem, bending strain energy.(6)

Column & Struts: - Analysis of long & short column by Euler's formula, Rankine's formula.(4)

Unit –VI:

Stresses in cylinders and spherical shells : Stresses in cylinders & spheres subjected to internal pressure, deformation of thick and thin cylinders, deformation in spherical shells subjected to internal pressure, Compound cylinders. (5)

Stresses in Rotating Disc: Stresses in thin rotating ring, disc of uniform thickness. (3)

Tutorials: Students will have to solve two problems on each unit.

Text Books

1. Strength of Materials by S.S. Rattan, McGraw-Hills Education (India) Publication, India.
2. Strength of Materials by S.S. Bhavikatti, Vikas Publishing house, Noida, India.
3. Strength of Materials by S. Ramamruthm & R. Narayanan, Dhanpat Rai Publishing Company, New Delhi, India.

Reference Books

1. Strength of Materials by F. L. Singer, Harper and row Publication.
2. Strength of Materials by R. Subramanian, Oxford University Press, USA.
3. Engineering Mechanics of Solid by Egor P. Popov, Prentice Hall of India Publication.
4. Mechanics of Materials by Beer, Johnson, Dewolf, Mc Graw Hill Publication.
5. Mechanics of materials by Timoshenko and Gere, CBS Publisher.

IV Semester
Department of Mechanical Engineering

Course Code : MET264 **Course : Fluid Mechanics & Hydraulic Machines**

L: 3 Hrs. T: 1 Hrs. P: 0 Hrs. Per week **Total Credits : 04**

Course Objectives

To enable the students to gain basic knowledge on fluid statics, dynamics and to understand laws of fluid mechanics and evaluate pressure, velocity, acceleration fields for various fluid flows. Also to understand performance of Hydraulic Machines.

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Understand the different types and properties of the fluid and learn various methods to measure pressure.
2. Evaluate the fluid flow kinematics for fluids in motion and apply basic principles of fluid dynamics.
3. Apply flow theories to engineering flow systems also understand flow through different pipes.
4. Understand effect of hydrodynamic force on various types of vanes.
5. Apply acquired knowledge to design and performance characteristics of hydraulic turbines.
6. Design and evaluate performance characteristics of centrifugal and reciprocating pump.

Syllabus

UNIT-1 : Definition of fluid, Newton's law of viscosity, Units and dimensions-Properties of fluids, mass density, specific volume, specific gravity, viscosity, compressibility and surface tension, Control volume- application of continuity equation and momentum equation, Incompressible flow,(8)

UNIT-2 : Continuity equation in one & three dimensions, differential velocity field Stream function, stream line, type of flow, kinematics flow (introductory treatment).Dynamics of flow -. Eulers equation of motion. Bernoulli's equation & its limitation. Application of Bernoulli's theorem,:- Venturimeter, orifice meter, pitot tube. (9)

UNIT -3 : Introduction to laminar and turbulent flow, Reynolds number and its Significance. Flow of viscous fluids through pipe .Exact flow solutions in channels and ducts, Couette and Poisuielle flow, laminar flow through circular conduits and circular annuli- concept of boundary layer – measures of boundary layer thickness Boundary layer Theory, Flow through pipes, losses in the pipes, Flow Through Pipes: Losses in pipes. Darcy Weisbach equation, friction factor, Moody's diagram. (9)

UNIT-4 : Impact of jet and jet propulsion: Momemtum principle, Dynamic action of jet on fixed and moving plates, curved vanes, series of plates and vanes, velocity triangles and their analysis, Introduction to hydroelectric power plant (8)

UNIT-5 : Classification of water turbines, heads and efficiencies, velocity triangles- Axial, radial and mixed flow turbines- Pelton wheel, Francis turbine and Kaplan turbines, working principles –draft tube- Specific speed, unit quantities, performance curves for turbines – governing of turbines. (8)

UNIT-6

Theory of Rotodynamic machines – Various efficiencies , velocity components at entry and exit of the rotor, velocity triangles – Centrifugal pumps, working principle, work done by the impeller, performance curves ,Cavitation in pumps, Reciprocating pump – working principle. (8)

Text Books

1. Fluid Mechanics & hydraulic machines, R.K. Bansal, Laxmi Publications.
2. Fluid Mechanics & Fluid Power Engineering, D. S. Kumar -S. K. Kataria Publications.
3. Fluid Power with Applications, Anthony Esposito, 7th edition, Pearson Publication.

Reference Books

1. Fluid Mechanics: Som & Biswas - Tata McGraw-Hill.
2. Hydraulic Machines - Theory & Design: V. P. Vasandani- Khanna Publishers.
3. Theory of Turbo-Machines: A. T. Sayer- McGraw Hill.
4. A text book of Fluid Mechanics : R.K. Rajput, S.Chand Publication.

IV Semester
Department of Mechanical Engineering

Course Code : MEP 264 **Course : Fluid Mechanics & Hydraulic Machines Lab**

L: 0 Hrs. T: 0 Hrs. P: 2 Hrs. Per week **Total Credits : 01**

Course Objectives

The objective of this course is to give practical insite on constructional details of various hydraulic machines also to enable the students to evaluate performance of these machines. The objective is also to understand various losses in pipes and to determine CD, CC and CV.

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Use knowledge of various discharge measuring devices such as orifice, mouthpiece and venturi meter for determining Cd, Cc, Cv.
2. Determine the major and minor losses in the various pipes
3. Graphically present the output of Impulse and Reaction turbines
4. Ability to perform practicals of rotodyanamic pump and positive displacement pump

The laboratory will have minimum Eight Practical based on the syllabus of MET-264 List of Experiments

1. Determination of coefficient of discharge for Venturi meter
2. Determination of coefficient of discharge for Orifice meter
3. Determination of hydraulic coefficients C and C for orifice d c
4. Determination of hydraulic coefficients C and C for mouthpiece d c
5. Determination of Darcy Friction factors for different pipes
6. To calculate efficiency of Pelton turbine
7. To calculate efficiency of Francis turbine
8. To calculate efficiency of Centrifugal pump
9. To calculate efficiency of Reciprocating pump
10. To determine minor losses in pipe flow

IV Semester
Department of Mechanical Engineering

Course Code : MEP265 **Course : Mechanical Engineering Software Lab**

L: 0 Hrs. T: 0 Hrs. P: 2 Hrs. Per week **Total Credits : 01**

Course Objectives

1. To understand and create solid model of parts and implement high level language program.
2. To develop the ability for project planning and data analytic required in bydinell application.

Course Outcomes

Upon successful completion of the course, student should be able to:

1. Explore and understand the modeling of machine components using geometric modeling software.
2. Program, understand importance and implementation Software languages for Mechanical applications.
3. Understand and implement the Project planning and Business analytics tools.
4. Understand Data Science and Data Analytics tools.

Syllabus

Module 1 Solid Modeling Software's

Machining simulation using CAM software (CREO 2.0, Catia V6, Delmia) Web based Software- On Shape.

Module 2 Programming

Mat LAB Sci LAB

Module 3 Project Planning / Business Analytics

Exposure to Project Planning and Business Analytics Tools. Financial Decision support systems. Introduction manufacturing execution system.

Module 4 Data Analytics

Python, Introduction to Num Py , Sci Py, Pandas, Stats Models, Matplotlib

Introduction to R Programming.

Text Books

1. Parametric Modeling with Creo Parametric 2.0 by Randy Shih, SDC Publications.
2. Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers, RudraPratap, Oxford University.

Reference Books

1. Reference manuals for Creo 2.0 of PTC University
2. Reference Manual For OnShape of Onshape domain.
3. Training material by TATA Technology Ltd. (CIIIT)

IV Semester
Department of Mechanical Engineering

Course Code : CHT252 **Course : Environmental Science**

L: 2 Hrs. T: 0 Hrs. P: 0 Hrs. Per week **Total Credits : 00**

Course Outcomes

On successful completion of the course, the students:

1. Will get sufficient knowledge regarding different types of environmental pollutions, their causes, detrimental effects on environment and effective control measures.
2. Will realize the need to change an individual's outlook, so as to perceive our environmental issues correctly, using practical approach based on observations and self learning.
3. Will become conversant with recent waste management techniques such as E-wastes, its recycling and management.
4. Will gain knowledge about the modes for sustainable development, importance of green energy and processes.
5. Will be able to identify and analyze environmental problems as well as risks associated with these problems and greener efforts to be adopted, to protect the environment from getting polluted.

Syllabus

Principle of contaminant behaviour and recent trends in environmental pollution control

I- Air pollution and its control techniques: (4 lectures)

Contaminant behaviour in the environment, Air pollution due to SOx, NOx, photochemical smog, Indoor air pollution

Natural pathways for degradation: Carbon cycle, Sulphur cycle, Nitrogen cycle, Oxygen cycle.

Factors responsible for altering the composition of atmosphere (deforestation, burning of fossil fuels, industrial and vehicular emissions, CFCs).

Techniques to control Air pollution, ambient air quality and continuous air quality monitoring, Control measures at source, Kyoto Protocol, Carbon Credits.

II- Noise pollution and its control techniques: (2 lectures)

Introduction to noise pollution and its causes

Noise pollution control: Recent advances in noise pollution control and benefits.

III- Soil pollution and its control techniques: (5 lectures)

Soil pollution: Soil around us, Soil water characteristics, soil pollution. Solid waste management: Composting, vermiculture, landfills, hazardous waste treatment, bioremediation technologies,

conventional techniques (land farming, constructed wetlands), and phytoremediation. Degradation of xenobiotics in environment: Petroleum hydrocarbons, pesticides, heavy metals.

IV- Water pollution and its control techniques: (8 lectures)

Major sources of water pollution: Eutrophication, acid mine drains, pesticides and fertilizers, dyeing and tanning, marine pollution, microplastics

Techniques to control water pollution: Conventional waste water treatment-types of sewage, sewerage system, alternative systems, primary, secondary and tertiary processes including aerobic and anaerobic techniques, safe disposal.

Case studies

Treatment schemes for waste water from dairy, textile, power plants, pharmaceutical industries, and agro based industries such as rice mills

V- E-wastes (2 lectures)

Introduction, types of e-wastes, environmental impact, e-waste recycling, e-waste management rules.

VI- Environmental Sustainability: Role of Green technology (5 lectures)

Concept of green technologies, categories, goals and significance, sustainability Green energy, green chemistry, challenges to green technology, advantage and disadvantages of green processes, Eco mark certification- its importance and implementation

Different government initiatives (2 lectures)

Books suggested

1) Benny Joseph, Environmental Studies, Mc Graw Hill Education (India) Private Limited
2) B. K. Sharma, Environmental Chemistry, Goel Publishing House, Meerut
3) P Aarne Vesilind, J. Jeffrey Peirce and Ruth F. Weiner, Environmental Pollution and Control, Butterworth -Heinemann
4) D. D. Mishra, S. S. Dara, A Textbook of Environmental Chemistry and Pollution Control, S. Chand & Company Ltd. Sultan Chand & Company
5) Shree Nath Singh, Microbial Degradation of Xenobiotics, Springer-Verlag Berlin Heidelberg
6) P.T. Anastas & J.C. Warner, Green Chemistry: Theory & practice, Oxford University Press
7) P. Thangavel & Sridevi, Environemental Sustainability: Role of Green technologies, Springer publications.

IV Semester
Department of Mechanical Engineering

Course Code : MEP270 **Course : Mini Project**

L: 0 Hrs. T: 0 Hrs. P: 2 Hrs. Per week **Total Credits : 02**

Course Objectives

To enable the students to design and fabricate the working model based on various application in mechanical engineering.

Course Outcomes

1. Ability to develop the habit to work in a group.
2. Ability to relate the theory knowledge to the fabrication work.
3. Students shall know the basic principles & their applications to mechanical engineering.
4. Ability to convert the innovative or recent technologies in the form of working model.

Syllabus

A group of students (not more than 5 students in a group) should fabricate a working model of any mechanical or electro-mechanical system.

Computer / mathematical model or simulation is not acceptable.

Students should submit (at least) one page abstract and a photograph of the model.

IV Semester
Department of Mechanical Engineering (Open Elective - I)

Course Code : MET299-1 **Course : Basic Mechanical Engineering**

L: 3 Hrs. T: 0 Hrs. P: 0 Hrs. Per week **Total Credits : 03**

Course Objectives

To gain the basic knowledge of mechanical engineering domain.

Course Outcomes

Students will be able to

1. Understand the mechanical properties of engineering materials and metal forming processes.
2. Understand the machine tools and various machining operations.
3. Understand the working of automobiles and power transmission system components.
4. Understand the laws of thermodynamics, thermodynamic cycles and heat transfer.
5. Understand the concept and working of refrigeration and air conditioning systems.
6. Understand the concept and working principles of energy conversion devices.

Syllabus

Unit I :

Engineering Materials: Introduction to Engineering Materials, Classification and Properties, stresses and mode of failure.

Manufacturing Processes: Castings - Patterns & Moulding, Hot Working and Cold Working,

Metal Forming processes: Extrusion, Drawing, Rolling, Forging, Welding - Arc Welding & Gas Welding, Soldering, Brazing.

Unit II :

Machine Tools : Lathe - Types - operations, Drilling M/c - Types - Operations, Milling M/c - Types - Operations - Up & Down Milling, Shaping M/c –Operations, Quick Return Mechanism, Planer M/c.- Operations-Shaper Vs Planer, Grinding M/c-Operations.

Introduction to NC/CNC Machines.

Unit III :

Power Transmission: Transmission of Power, Belt drives, chain drive, rope drive, Gears and Gear Trains.

Automobile Engineering: Layout of an Automobile, major components and their functions (Brief description only), Transmission, Clutch, Differential, Brakes, Introduction to battery operated vehicles.

Unit IV :

Thermodynamics: Energy Sources - Conventional/Renewable, Laws of thermodynamics, significance and applications of thermodynamics, Ideal and real gas equations, Carnot cycle, Heat Pump, Refrigerator and Heat Engine, Otto, Diesel Cycle. Heat Transfer: Modes of Heat Transfer, Thermal Resistance Concept, Composite Walls & Cylinders, and Overall Heat Transfer Coefficient.

Unit V :

Refrigeration and Air Conditioning : Vapour compression refrigeration systems, Energy efficiency rating, Psychrometry, psychrometric process, Air conditioning systems and air conditioners, Refrigerants and their impact on environment.

Unit VI :

Energy Conversion Devices: Conventional power generation, Boiler, steam turbines, gas turbines, working principle of two stroke and four stroke IC Engines (SI and CI), Fuels, CRDI, MPFI, Reciprocating pumps, centrifugal pumps and hydraulic turbines, solar, wind, tidal, geothermal, power generation (Elementary idea only).

Text Books

1. Elements of Mechanical Engineering – R. K. Rajput Lakmi Publications, Delhi
2. Elements of Mechanical Engineering – D. S. Kumar, S. K. Kataria and Sons
3. Engineering Thermodynamics- P. K. Nag TMH, New Delhi
4. Refrigeration & Air conditioning – Arora & Domkundwar, Dhanpat Rai & Co. Pvt. Ltd
5. Workshop Technology Volt.I & II – Hazra & Chaudhary, Asian Book Company., New Delhi.

Reference Books

1. Hydraulic Machines – Jagdish Lal, Publication, Metropolitan, Allahbad.
2. Strength of Materials – G.H. Ryder, ELBS Publications.
3. Engineering Thermodynamics – C.P. Arora, TMH Publications, New Delhi
4. Refrigeration & Airconditioning- C.P. Arora. Pub. – TMH Publications , New Delhi Manufacturing Science – Amitabha Ghosh & Ashok Kumar Malik, East-West Press

IV Semester
Department of Mechanical Engineering (Open Elective - I)

Course Code : MET299-2 **Course : Non conventional Energy sources**

L: 3 Hrs. T: 0 Hrs. P: 0 Hrs. Per week **Total Credits : 03**

Course Objectives

1. To understand the need of alternate energy sources.
2. To understand basics of various non conventional energy technologies, working principles and constructional details.

Course Outcomes

The expected learning outcomes is that, the students will be able to

1. Recognize the need of non conventional energy sources.
2. Describe various solar thermal energy conversion systems.
3. Understand the basics of solar photovoltaic systems.
4. Describe the working principle of wind energy conversion systems.
5. Understand the biogas and biomass energy conversion systems.
6. Describe the ocean energy conversion systems.

Syllabus

Unit – I

World energy resources: Global energy scenario, Indian energy scenario, Environmental aspects of energy utilization, conventional and non conventional sources of energy, merits and challenges, Introduction to various renewable energy sources.

Unit – II

Solar thermal energy conversion: Solar radiation on the earth surface, Measurement of solar radiations, concentrating and non concentrating types of solar collectors, various solar thermal applications.

Unit – III

Solar electrical energy conversion: Construction and working of solar cells and PV modules, different PV technologies, Photovoltaic system components and different applications.

Unit – IV

Wind energy: Basic principle of wind energy conversion system, site selection consideration, basic components of WECS, classification of WEC systems, applications of wind energy.

Unit –V

Biogas: - Principle of bio gas generation, constructional details of various biogas plants, factors affecting generation of biogas and methods of maintaining biogas, Bio Mass: Introduction, methods of obtaining energy from biomass, thermal gasification.

Unit – VI

Ocean energy: ocean thermal electric conversion, open and closed cycle of OTEC, basic principles of tidal power & components of tidal power plants, single & double basin arrangements, Energy from ocean waves, wave energy conversion devices.

Text Books

1. G.D. Rai, 'Non Conventional Energy Sources', Khanna Publishers, New Delhi.
2. G. N. Tiwari and M. K. Ghoshal, Renewable Energy Sources Basic Principles and Applications, Narosa Publishing House, New Delhi.

Reference Books

1. John Twidell , Tony Weir , 'Renewable Energy Resources', Taylor & Francis; 2nd edition, 2005
2. Duffie, J. A. & W. A. Beckman, 'Solar Engineering of Thermal Processes', 3rd ed. John Wiley & Sons, Inc., 2006
3. C. S. Solanki, 'Solar Photovoltaics: Fundamental Applications and Technologies, Prentice Hall of India, 2009.
4. S.P. Sukhatme, Solar Energy: Principles of Thermal Collection And Storage, Tata Mcgraw-Hill

V Semester
Department of Mechanical Engineering

Course Code : MET351 **Course Name : Applied Thermodynamics - I**

L: 3 Hrs, T: 1 Hr, P: 0 Hrs. Per week **Total Credits : 04**

Course Objectives

The objective of the course is to prepare the students:

1. To familiarize with the different components of a steam power plant.
2. To improve the performance of thermal power plants.
3. To achieve and maintain optimum energy utilization to minimize energy cost and environmental effects.

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Understand the principle of steam generation and compute the performance of boiler and draught requirements.
2. Understand the various allied systems for efficient thermal power generation.
3. Understand the working principle of nozzles and turbines in steam power plants.
4. Evaluate the performance of the steam nozzles and steam turbines.
5. Analyze the steam condensation equipment for performance evaluation.
6. Recognize the cogeneration principle and various energy conservation opportunities in thermal power plant.

Syllabus

Unit – I:

Principle of Steam Generation, Classification of Steam Generators, High Pressure Steam generators, Supercritical steam generators, Boiler Mountings and Accessories Draught and Its Classification, Chimney Height, Chimney Diameter, Chimney Efficiency, Condition for Maximum Discharge. Performance of Steam Generators: Evaporation Capacity, Equivalent Evaporation, Boiler Efficiency.

Unit – II:

Fluidized Bed Boiler: Bubbling Fluidized Bed Boilers, Circulating Fluidized Bed Boilers Fuel for Steam Generators, Gradation & Analysis of Coal, Coal Handling System, Ash Collection and Handling System, Flue Gas Analysis, Feed Water Supply System.

Unit – III:

Steam Nozzles: Adiabatic Expansion in Nozzles, Maximum Discharge Critical Pressure Ratio and effects of Friction, Calculation of Throat and Exit Areas, Super saturation Flow, Wilson Line Steam Turbines Principle of Working of Steam Turbines, Classification of Steam Turbines, Comparison of Impulse and Reaction Turbines, Compounding of Steam Turbines.

Unit - IV:

Energy Losses in Steam Turbines, Flow of Steam Through Turbine Blades, Ideal and Actual Reheat Factors, Velocity Diagrams, Graphical and Analytical Methods, Work, Done, Thrust and Power, Dimensions and Proportioning of the Blades, Steam Turbine Efficiencies, Condition for maximum efficiencies, Reheat and Regenerative Cycles, Governing of steam Turbines.

Unit–V: Introduction to Steam Condensers: Types of Condensers, Classification of Condensers Quality of cooling water required, Design calculations for surface condenser, Dalton's Law of partial Pressures, Sources of Air leakages and Air Removal, Air Ejectors. Cooling Towers: Wet Cooling Towers, Dry Cooling Towers, Cooling Ponds.

Unit – VI:

Energy conservation opportunities in thermal power plant. Steam turbine cogeneration system: Need, Principle, Technical Options for Cogeneration, Technical Parameters for Cogeneration

Text Books

1. Rajput R. K., Thermal Engineering, Laxmi Publications.
2. Rathore M. M., Thermal Engineering, Tata McGraw Hill Education Pvt. Ltd.
3. Principles of Energy Conservation, Archie, W Culp, McGraw Hill, 1991

Reference Books

1. Domkundwar V.M., Power Plant Engineering, DhanpatRai and Co.
2. SelwinRajadurai J., Thermodynamics and thermal engineering, New Age International.
3. Vasandani and Kumar, Heat Engineering, Metropolitan.
4. Ballaney P.L., Thermal Engineering, Khanna Publications.
5. Bureau of Energy Efficiency Study material for Energy Managers and Auditors Examination

V Semester
Department of Mechanical Engineering

Course Code : MET352 **Course Name : Heat Transfer**

L: 3 Hrs, T: 0 Hr, P: 0 Hrs. Per week **Total Credits : 03**

Course Objectives

1. To understand basic of Heat Transfer Mechanisms governing laws and their applications in heat transfer analysis.

Course Outcomes

1. Understand and analyze basic modes of heat transfer and apply mathematical equations to analyse steady state heat conduction.
2. Analyze heat conduction with internal heat generation, extended surfaces and unsteady state heat transfer.
3. Demonstrate the concept and mechanism of forced convection for flow over flat plate, external, internal flows through conduits.
4. Understand the concept of natural convection, boiling and condensation.
5. Understand the basic laws of radiation heat transfer and their applications.
6. Explain the design, performance analysis and practical applications of heat exchangers.

Syllabus

Unit –I: Introduction, Basic modes of Heat Transfer, Conduction, Convection and Radiation, Laws of Heat Transfer, General Heat conduction equation in Cartesian, Cylindrical and Spherical Co-ordinates, Thermal conductivity and diffusivity, One dimensional steady state conduction equation for the plane wall, Cylinder and Sphere, Thermal resistance of composite structures, Contact resistance, overall heat transfer coefficient, critical thickness of insulation.

Unit – II: Conduction with internal heat generation for plane wall, Cylinder and sphere, Extended Surfaces, Types of Fins, Fins of uniform cross section area, temperature distribution and their heat transfer rate, Fin efficiency and effectiveness, Unsteady state Heat transfer, Lumped Heat Capacity analysis, Heisler charts, Biot number, Fourier number and their significance.

Unit – III : Forced convection, physical significance of non dimensional parameters, Flow of high, moderate and low Prandtl number fluid over flat surface, Concept of velocity and thermal boundary layer thickness, Local and average Heat Transfer coefficient, empirical co-relation for external, internal flow, Laminar and turbulent flow through conduits.

Unit – IV : Free or Natural Convection, Grashoff number, Rayleigh number, horizontal and vertical plate, empirical correlations for Cylinders and sphere, Heat transfer with phase change, pool boiling curve and regimes of pool boiling, film and drop wise condensation, Laminar film condensation on vertical surface, Film condensation on horizontal tubes, effect of superheated and non condensable gases on condensation heat transfer, Introduction to heat pipe.

Unit - V : Radiation, nature of thermal radiation, black body radiation, radiation intensity, laws of radiation-Kirchoffs, Planks, Weins displacement, Stefen-Boltzmann and Lamberts Cosine law, Emissivity, absorptivity, transmissivity, reflectivity, radiosity, emissive power, irradiation, Radiation network, radiation exchange between surfaces, idea of shape factor and reciprocity theorem, radiation between parallel plates, Cylinder and sphere, radiation shields, effect of radiation on temperature measurement.

Unit – VI : Heat exchanger : classification, overall heat transfer coefficient, Fouling factor, LMTD method of heat exchanger analysis, Analysis for parallel, counter flow and cross flow arrangement, effectiveness-NTU method, heat exchanger analysis by NTU method , design aspects of heat exchangers, introduction to compact heat exchanger.

Text Books

1. Heat and Mass transfer, Y. A. Cengel, McGraw Hill.
2. Incropera & Dewitt J. Wiley, Introduction to Heat Transfer, John Wiley & Sons.
3. Ozisik M.N., Elements of Heat Transfer, Mc Graw Hill.
4. Sukhatme S.P., Heat Transfer, Universities Press.

Reference Books

1. Holman J. P., Heat Transfer, Mc Graw Hill.
2. Kumar D. S., Heat Transfer, S K Kataria & Sons.
3. Kothandaraman C. P., Fundamentals of Heat & Mass Transfer, New Age Techno Press.
4. M Tirumaleshwar, Fundamentals of Heat & Mass Transfer, Pearson.

V Semester
Department of Mechanical Engineering

Course Code : MEP352 **Course Name : Heat Transfer**

L: 0 Hrs, T: 0 Hr, P: 2 Hrs. Per week **Total Credits : 01**

Course Objectives

1. To understand various modes of heat transfer factors affecting the rate of heat transfer and thermal performance of various heat transfer systems.

Course Outcomes

1. To analyse steady state conduction heat transfer in various geometries.
2. To analyse natural and forced convention in various arrangements.
3. To understand radiation heat transfer in different geometries.
4. To carry out performance analysis of heat exchangers.

List of Experiments

1. To determine thermal conductivity of composite wall.
2. To determine thermal conductivity of insulating powder.
3. To determine thermal conductivity of lagging material.
4. To determine thermal conductivity of metal rod.
5. To determine the critical heat flux.
6. To determine heat transfer coefficient in natural convection.
7. To determine heat transfer coefficient in forced convection.
8. To determine heat transfer coefficient for a pin fin in natural and forced convection.
9. To determine effectiveness of heat pipe.
10. To determine emissivity of a test plate.
11. To determine Stefan Boltzman constant
12. To determine the effectiveness of a concentric tube heat exchanger.

V Semester
Department of Mechanical Engineering

Course Code : MET353 **Course : Design of Machine Elements - I**

L: 3 Hrs, T: 1 Hr, P: 0 Hrs. Per week **Total Credits : 04**

Course Objectives

Students should apply the concepts of mechanics of solid and material science to design commonly used machine components by considering various design consideration to fulfill the need of society.

Course Outcomes

At the end of this course students will able to

1. Understand the need, steps of machine design, Design consideration for various process.
2. Design of various temporary and permanent joints.
3. Design of machine components against fluctuating loads.
4. Design Power screw and springs for various applications.
5. Design of flywheel and mechanical brakes for various applications
6. Design the transmission shafts, and keys.

Unit I

Introduction to Machine Design : Definition of Machine Design, types of Machine Design, Basic procedure of design process. Failure of machine elements due to deformations, wear, corrosion. Design consideration in casting & forging. Mechanical properties of materials, Designation of steel, selection of material, preferred number. Aesthetic and ergonomic considerations in design. Theories of failure.

Unit II

Design against static loads : Design of cotter and Knuckle joint. Design of riveted point, bolted point, welded point subject to concentric and eccentric loading.

Unit III

Design against fluctuating loads : Stress concentration, Fluctuating stresses, Fatigue failure, Notch sensitivity, Soderberg and Goodman criterion, Design of mechanical components subjected to dynamic loading for finite and infinite life.

Unit IV

Design of Power Screw : Terminology of power screw, types of power screw, Design of screw jack and toggle jack. Simple applications of power screw.

Design of Mechanical Spring : Terminology of spring and its types. Design of helical compression and tension spring. Design of Leaf Spring.

Unit V

Design of Flywheel : Necessity of flywheel in IC engine and punching press, design parameters, stresses developed in rim, arm of flywheel.

Design of Brakes: Requirement, Kinematics of friction drives, Design of Block brake, band brake, band and block brake, internal expanding shoe brake. Thermal consideration in braking system.

Unit VI

Design of transmission Keys and Shafts : Design of shaft on the Basis of Strength, rigidity and critical speed. ASME Code for shaft Design, Design of splines and keys.

Text Books

1. Bhandari V.B., Design of Machine Elements, Tata Mc-Graw Hill publications.
2. Shigley J. E., Mechanical Engineering Design, Tata Mc-Graw Hill publications.
3. Jain R.K., Machine Design, Khanna Publisher, Delhi.

Reference Books

1. Grover O. P. , Maleeve and Hartmans Machine Design, Fifth Edition, CBS Publisher and distributers PVT. LTD.
2. Black P. H., Machine Design, Mc-Graw Hill publications.
3. Norton, Machine Design, Pearson publication.
4. PSG- Design Data Book.
5. Shiwalkar B. D., Design Data for Machine Elements, Central Techno Publication.

V Semester
Department of Mechanical Engineering

Course Code : MET354 **Course : Manufacturing Technology**

L: 3 Hrs, T: 0 Hr, P: 0 Hrs. Per week **Total Credits : 03**

Course Objectives

The objective of the course is to prepare the students:

1. To understand the tooling needed for manufacturing, tolerance systems and design assembly gauges.
2. To understand the dimensional accuracy in measuring equipment and apply Quality Control techniques in the manufacturing process.

Course outcomes

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

1 To provide knowledge on machines and related tools for manufacturing various components.

2 Develop conceptual understanding of tolerance systems and design assembly gauges.

3 Interpret different production operations and prepare the tolerance chart.

4 Develop and apply knowledge of engineering metrology and measuring equipment.

5 Analyze and interpret technical data through Quality Control techniques.

6 Analyze the quality assurance of the products and process management.

UNIT – I

Tooling for conventional and non-conventional machining processes, mould and die design, press tools – configuration, working of die and punch; principles of forging die design. jigs and fixtures, principles, design and applications.

UNIT – II

Limits, fits and tolerances, tolerances limits, types of fits, types of allowances, shaft basis system and hole basis system, tolerance analysis in assembly, taylor's principle, design of limit gauges.

UNIT – III

Interpretation and significance of process planning, steps in process planning, preparation of tolerance chart, classification of operations, sequencing of operations, selective assembly, interchangeability.

UNIT – IV

Metrology: definition, standard of measurements, methods of measurement, instruments for linear and angular measurements, measurement of straightness and flatness, measurements of thread, characteristics of surface finish, precautions while using an instrument for getting higher precision and accuracy.

UNIT – V

Quality and quality control: definition, function, objective and characteristics. quality of design and conformance, statistical quality control (SQC), process capability and control limits, causes of variation, control charts for variables and attributes.

UNIT – VI

Acceptance sampling for inspections, comparison with 100% inspection, different types of sampling plans, OC curve- importance and significance, producers risk, consumer's risk, production planning and control, types and characteristics of production systems, Total quality management.

Text Books

1. Hajna Choudhary S. K. Workshop Technology, MPP Pvt. Ltd.
2. Jain R.K., Engineering Metrology, Khanna Publications, Delhi
3. Mahajan M., Statistical Quality Control, Dhanpat Rai Publications, Delhi

Reference Books

1. Sharma P.C., Production Engineering, S. Chand Publications, Delhi
2. Grant E. L., Statistical Quality control, Mcgraw-Hill, Delhi (Noida)
3. Khanna O. P., Production Technology, Dhanpat Rai Publications, Delhi

V Semester
Department of Mechanical Engineering

Course Code : MEP354 **Course : Manufacturing Technology**

L: 0Hrs, T: 0 Hr, P: 2 Hrs. Per week **Total Credits : 01**

Course Objectives

The objective of the course is to prepare the students:

1 To handle the various precise engineering tools and equipments and

2 To interpret technical data through quality control techniques

Course outcomes

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

1. understand the knowledge of engineering metrology, its working principles and various measurement practices.
2. Learn to handle the various modern engineering tools and equipments for linear and angular measurements
3. interpret technical data of the various precise instruments Tool Maker's Microscope, Profile projector, etc.
4. design and learn from case studies on assembly fits & limits gauges
5. learn from case study approach on Quality Control Techniques

List of experiments based on following topics:

Expt 1. Measurement of linear dimensions with Vernier Caliper.

Expt 2. Measurement of linear dimensions with Vernier height gauge & depth gauge.

Expt 3. Measurement of linear dimensions with Micrometer screw gauge.

Expt 4. Measurement of angular dimensions with bevel protector.

Expt 5. Measurement of angular dimensions with sine bar and slip gauges.

Expt 6. Measurement of straightness with Autocollimator.

Expt 7. Study and use of Optical flat.

Expt 8. Measurement of screw dimensions using Tool Maker's Microscope.

Expt 9. Measurement of screw dimensions using Profile projector.

Expt 10. Case study: To study in detail the power presses.

Expt 11. Case study. To learn from case studies on design of assembly fits & limits gauges

Expt 12. Case study. To learn from case study approach on Quality Control TechniquesText

Books

1 Kalpakjian and Schmid, Manufacturing processes for engineering materials, Pearson India

2 Jain R.K., Engineering Metrology, Khanna Publications, Delhi

3 Mahajan M., Statistical Quality Control, Dhanpat Rai Publications, Delhi

Reference Books

1. Sharma P.C., Production Engineering, S. Chand Publications, Delhi

2. Grant E. L., Statistical Quality control, Mcgraw-Hill, Delhi (Noida)

3. Khanna O. P., Production Technology, Dhanpat Rai Publications, Delhi

V Semester
Department of Mechanical Engineering

Course Code : MET355 **Course : Operations Research**

L: 3 Hrs, T: 0 Hr, P: 0 Hrs. Per week **Total Credits : 03**

Course Objective

1. To impart knowledge in concepts and tools of Operations Research.
2. To use techniques for effective decisions–making; model formulation and applications that are used in solving business decision problems

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Convert given situation to mathematical form and determine optimal settings.
2. Apply LPP tool to determine optimal settings in various applications.
3. Use sequential optimization approach to find optimal setting in many real-life situations.
4. Manage projects for minimum total cost and smooth level of resources.
5. Make decisions related to age of replacement of equipment
6. Develop simulation of real-life system to analyse and optimize system concerned.

Unit – I :

Definition Characteristics and limitations of OR, linear programming, solutions of LPP by graphical method and simplex method, Duality theory, Sensitivity analysis, use of software to solve LPP.

Unit – II :

Assignment Model, Travelling Salesman Problem by branch and bound method, Transshipment model, Transportation Model

Unit – III :

Dynamic programming structure and characteristics of Dynamic programming application of Dynamic programming to resource allocation

Unit – IV :

Project Management: Drawing of Network, CPM & PERT, probability of completion of project, cost analysis, Allocation and updating of Networks, Project Management Software.

Unit – V :

Replacement Models: Concept of equivalence, Interest Rate, Present worth, economic evaluations of Alternatives, Group replacement models. Use of spreadsheet tool to solve replacement problem

Unit – VI :

Inventory control models, Simulation, concepts and its application in inventory control, and in waiting line situations (queuing situations) and other applications.

Text Books

1. Heera & Gupta, Operation Research: S Chand Publications
2. J K Sharma, Operation Research: McMillian Publications
3. Panneer Selvam Operations Research: TMH Publications

Reference books

1. Hamdy Taha, Operation Research, Prentice Hall
2. Liberman, Operation Research, McGraw Hill Publications
3. S D Sharma Operation Research, Kedarnath Ramnath & Co.
4. Paul A. Jensen and Jonathan F. Bard, Operations Research: Models and Methods John Wiley and Sons.

V Semester
Department of Mechanical Engineering

Course Code : MET398-1, Open Elective-II | **Course : Project Management**

L: 3 Hrs, T: 0 Hr, P: 0 Hrs. Per week | **Total Credits : 03**

Course Objective

1 The students will learn the tools and techniques for effective management of resources and cost in projects.

2 The students will discover various network techniques used in project management.

3 Students will be introduced to computerized project management systems.

Course Outcomes

Students will be able to:

1. Understand the terminology of Project Management.
2. Portray the project management environment and functions.
3. Describe Performance Measurement in project management.
4. Identify the resources needed for each stage, including involved stakeholders, tools and supplementary materials.
5. Demonstrate the Network Scheduling Techniques and Project Graphics.
6. Provide internal stakeholders with information regarding project costs by considering factors such as estimated cost, variances and profits.

UNIT 1:

Overview of Project Management, Classification of Projects, Project Management Growth: Concepts and Definitions, Organizational Structures used in Project Management

UNIT 2:

Organizing and Staffing the Project Office, Team Management Functions in a Project Environment, the Project Organizational Chart, Management of time and stress conflicts

UNIT 3:

Special Topics in Project Management, Working With Executives, Performance Measurement, Financial Compensation and Rewards, Effective Project Management in the Small Business Organization

UNIT 4:

Project Planning, the Statement of Work, Project Specifications, Milestone Schedules, Work Breakdown Structure, WBS Decomposition Problems, Role of the Executive in Project Selection

UNIT 5 :

Network Scheduling Techniques, Project Graphics

UNIT 6:

Introduction, Understanding Control, the Operating Cycle, Budgets, Variance and Earned Value, Status the Bathtub Period, Methodology for Trade-off Analysis, Contracts

Text book

1. Harold Kerzner, Project Management A Systems Approach to Planning, Scheduling and Controlling, Eight Edition, Wiley & Sons, Inc.
2. Nagarajan K., Project Management, Second Edition, New Age International Publishers.

Reference Book

1. Harold Kerzner, Project Management with Workbook Case Studies Microsoft Project 2002 Trial Edition and Student Survey Set, 8th Edition, Wiley & Sons, Inc., 2004.

V Semester
Department of Mechanical Engineering

Course Code: MET 398-2, Open Elective-II **Course : Automobile Engineering**

L: 3 Hrs, T: 0 P: 0 Hrs. per week **Total Credits: 03**

Course Objectives

1. To give insight of various systems and subsystems that constitute the modern automobile and the latest trends.
2. To provide an overview of automotive emissions and details of electric vehicles.

Course Outcomes

1. Recognize and illustrate the working of various powertrain and transmission components.
2. Identify and explain the working of different types of steering, suspension, and braking system in the automobile.
3. Express the need and functioning of mechatronics, passenger safety devices and recent trends in automobile.
4. Identify the cause of automotive pollution and demonstrate the various after treatment devices for pollution control.
5. Justify the need of e-mobility and appraise the basics of electric vehicles along with the policy, technology and business perspective.
6. Categorise and examine various types of battery chemistry, motors and chargers available for electric vehicles.

Syllabus

Unit-1

Powertrain & Transmission Components: Engine types, Electronic Fuel Injection system, CRDI, Clutch, Gearbox, driveline components, Differential

Unit 2

Running Gear and Controls: Tyres its types and application, Suspension system, Independent suspensions, shock absorbers, steering mechanism, power Steering brakes, drum and disc brakes, hydraulic and pneumatic brakes.

Unit3

Electricals, Auto-mechatronics and Vehicle Safety: Starter Motor, Ignition system, Alternator, Active and Passive Safety, Airbags, Crumple Zone, Collision Avoidance, Adaptive Cruise Control, Intelligent Lighting etc.

Unit 4

Vehicle Emissions and Control Strategies: Causes and Methods to reduce vehicular pollution, after treatment devices, Catalytic Converter, EGR, SCR etc.

Unit 5

Introduction to Electric Vehicle: Need of EV and its types, EV configurations, factors affecting electric vehicle adoption. Policy, Business and Technology perspective of EV. Electric vehicle infrastructure, fast and slow charging.

Unit 6

Electric Car Technology: Battery for EVs- types, chemistry, suitability. Motors for EVs, Fuel Cells, Chargers, Converters.

Text Book

1. Kirpal Singh, Automobile Engineering Vol. 1 & Vol. 2, Standard Publishers.
2. G.B.S. Narang, Automobile Engineering, Khanna publisher.
3. Mehrdad Ehsani, Yimin Gao, Stefano Longo, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, CRC Press.

Reference Book

1. GanesanV., Internal Combustion Engines, Mc-Graw Hill pub.
2. Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals", Third Edition, CRC Press, 2018.

V Semester
Department of Mechanical Engineering

Course Code : HUT353 **Course : Indian Traditional Knowledge**

L: 2 Hrs, T:0 Hrs, P: 0 Hrs. Per week **Total Credits : 00**

Course Objectives

The course is designed with the objets of developing understanding of the students about the essence of India traditional knowledge in terms of its scientific approach, legality, role in natural resource protection, as well as its contribution to philosophy and art.

Course outcome

Students will have increased ability to understand the importance and application of:

CO1: Indian Knowledge system and its scientific approach

CO2: Traditional knowledge and protection of nature

CO3: The legality and its importance for the protection of Indian traditional knowledge

CO4: Indian philosophical tradition

CO5: Indian artistic tradition

Syllabus

1. Basic Structure of Indian Traditional Knowledge: Vedas, Upavedas, Vedang, Upadang, scientific approach
2. Ecology and Indian Traditional Knowledge: Meaning, role, case studies
3. Intellectual Property Rights and Indian traditional Knowledge: Meaning, role in protection of Indian traditional knowledge, cases studies
4. Indian Philosophical traditions: Nyay, Sankaya, Yog, Mimansa, Jainism, Buddhism, Sikhism, and other approaches
5. Indian Artistic Traditions: Chitrakala, Murtikala, Vastukala, Sangeet, Sthpatya, Nritya evam Sahitya, case studies
6. Knowledge of traditional Indian Science and Technology

Reference Material

1. Amit Jha (2009), Traditional Knowledge System in India, Atlantic Publishers and Distributors.
2. RR Gaur, Rajeev Sangal, GP Bagaria, Human Values and Professional Ethics (Excel Books, New Delhi, 2010)
3. V. Sivaramakrishanan (ed.), Cultural Heritage of India – Course material, Bharatiya VidyaBhavan, Mumbai, 5th Edition, 2014

4. Swami Jitatmanand, Modern Physics and Vedant, Bharatiya VidyaBhavan
5. Swami Jitatmanand, Holistic Science and Vedant, Bharatiya VidyaBhavan
6. S.C. Chatterjee and D.M. Datta, An introduction to Indian Philosophy, University of Calcutta, 1984
7. Pramod Chandra, Indian Arts, Howard University Press, 1984
8. Krishna Chaitanya, Arts of India, Abhinav Publications, 1987 9.
9. https://www.researchgate.net/publication/299625768_Traditional_Knowledge_systems_in_India_for_biodiversity_conservation/link

V Semester
Department of Mechanical Engineering

Course Code : MEP360 **Course Name : Project-I**

L: 0 Hrs., T: 0 Hrs., P: 2 Hrs., Per week **Total Credits : 01**

Course Objectives

The objective of the course is to prepare the students:

1. To encourage self-study competence.
2. To describe, interpret and analyze the technical problems.
3. To develop technical writing and oral communication skills.

Course outcomes

Student will be able to:

1. Identify the theme/topic for the Technical Seminar
2. Review the literature online/offline of the selected theme/topic from Journals/ Conferences/ reference books
3. Compile the reviewed literature in viewpoint with topic selected.
4. Interpret the topic of technical seminar including application, merits & limitations
5. Improve confidence in presentation skills and techniques.

The seminar topic should be latest and ahead of the scope of curriculum. The literature review should be conducted from at least four most recent research papers published in reputed journals. A Student should prepare two spiral bound copies of the Seminar report. The student should submit the report of the seminar in duplicate, typed on A4 size sheet preferably 20 to 25 pages in a prescribed format. The performance of the student will be evaluated on the basis of the contents, the presentation and discussion during the delivery of the seminar in front of the evaluation committee appointed by the Department.

VI Semester
Department of Mechanical Engineering

Course Code : MET361 **Course : Applied Thermodynamics II**

L: 3 Hrs, T:0 Hrs, P: 0 Hrs. Per week **Total Credits : 03**

Course Objectives

1. To teach the students about various efficiencies and performance parameters of reciprocating and rotary compressors.
2. To understand various components, combustion phenomenon and heat balance for SI and CI engines.
3. To enable the students to evaluate the performance of refrigeration and air conditioning systems.
4. To analyze the performance of gas turbine plants and various jet propulsion systems.

Course Outcomes

1. Understand the thermodynamics and various efficiencies of reciprocating air compressors.
2. Understand the construction, working and various efficiencies of rotary compressors.
3. Analyze air standard as well as actual cycles and Compute the performance parameters of I.C. Engines.
4. Evaluate the coefficient of performance of various refrigeration systems and understand the psychrometric processes for air conditioning systems.
5. Analyze the gas turbine cycles and understand the methods of improving its performance.
6. Understand the construction, working and performance evaluation of various types of jet engines.

Syllabus

Unit - I

Positive displacement Compressors : Reciprocating compressors: - Parts, Operations, Work done during isothermal, polytropic & adiabatic compression process, isothermal efficiency, Effect of clearance, volumetric efficiency, Mechanical efficiency, Multistage compressor, condition for minimum work input, capacity control, Actual indicator diagram.

Unit - II

Rotary Compressors : Rotary & vanes blower and screw compressor: - Principle, operation, parts, indicator diagram, work done, Roots efficiency, vane efficiency.

Centrifugal compressor: - Principle, operation, parts, velocity diagram, static & total head quantities, work done by impeller, isentropic efficiency of compressor, slip factor, pressure coefficient, power input factor. Axial flow compressor: Principle, operation, parts. velocitydiagram, work done, Degree

of reaction stage efficiency compressor characteristics, surging and choking, Polytropic efficiency.(No analytical treatment expected)

Unit – III

I.C. Engines : Air standard & fuel air cycles, parts of I.C. Engines, working of I.C. Engines, Two stroke & four stroke I.C. Engines SI & CI engines, Introduction to combustion in SI & CI engine, carburetion & fuel injection. (Analytical treatment not expected)

I.C. Engine Testing:-Measurement of power: indicated, friction & brake power, measurement of speed, fuel & air consumption, calculation of indicated & brake thermal efficiency, volumetric efficiency, mechanical efficiency, percentage of excess air, Heat balance sheet.

Unit IV

Refrigeration : Introduction, unit of refrigeration, simple vapour compression refrigeration system. Alternative refrigerants, introduction to cryogenics and application of cryogenics, Air conditioning: Introduction, psychrometric properties and processes, human comfort and factors affecting comfort, Bypass factor, application of Psychrometrics to simple air conditioning systems,

Unit - V

Gas Turbines : Ideal cycles, isentropic and small stage efficiency, application of gas turbines, pressure losses, effect of inter-cooling, reheat & regeneration, fuel-air ratio, combustion efficiency, performance calculation, open cycle & closed cycle gas turbine plants, cogeneration & combined power cycles.

Unit - VI

Jet Propulsion : Principles & working of turbojet, turbo-prop, Ramjet & pulse jet. Simple turbojet cycle, Thrust power, propulsive power. Thermal efficiency, propulsive efficiency. Overall efficiency.

Text Books

1) Rajput R.K., Thermal Engineering, Laxmi publications.

2) Mahesh Rathore, Thermal Engineering, Mc-Graw Hill pub.

3) GanesanV., Internal Combustion Engines, Mc-Graw Hill pub.

Reference Books

1) Cohen & Rogers, Gas Turbine Theory, Longmans Green pub.

2) Charles Fayette Taylor, The Internal Combustion Engine in Theory and Practice Volume I & II, The MIT Press.

3) Khajuria & Dubey, Gas turbine & Jet Propulsion, Dhanpat rai & sons.

VI Semester
Department of Mechanical Engineering

Course Code : MEP361 **Course : Applied Thermodynamics II**

L: 0 Hrs, T:0 Hrs, P: 2 Hrs. Per week **Total Credits : 01**

Course Objectives

1. To teach the students various performance parameters of reciprocating and rotary compressors.
2. To understand heat balance sheet and combustion characteristics of SI and CI engines,
3. To enable the students to find coefficient of performance for vapor compression refrigeration system and demonstrate various psychrometric processes.
4. To understand the performance parameters for gas turbine plants and various jet propulsion systems.

Course outcomes:

1. Ability to analyse the various performance parameters and volumetric efficiency of reciprocating and rotary compressors.
2. Ability to know the performance characteristics by testing the S.I. and C.I.
3. Ability of Computing COP of computer based vapour compression refrigeration system.
4. Demonstrate the various air conditioning processes on computerized air conditioning tutor.
5. Understand the gas turbine and various jet propulsion systems with the help of fabricated models.

List of Practical

1. To determine the volumetric efficiency of a reciprocating air compressor test rig.
2. Study of components of internal combustion engines and to study the detailed comparison of S.I. and C.I. engines and 2-stroke and 4-stroke engines.
3. To conduct the performance test and study the p-V and p- diagrams for computerized single cylinder petrol engine test rig.
4. To conduct the performance test and study the p-V and p- diagrams for computerized single cylinder diesel engine test rig.
5. To study the effect of variation in compression ratio on various operating parameters of a variable compression ratio petrol engine set up.
6. To determine the C.O.P. of computerized vapour compression refrigeration test rig.
7. To demonstrate the various psychrometric processes on computerized air conditioning tutor.
8. Study of various gas turbine plants.
9. Study of various jet propulsion systems.
10. Report on visit to a cold storage/refrigeration plant.

VI Semester
Department of Mechanical Engineering

Course Code : MET-362 **Course : Instrumentation and Control**

L: 3 Hrs, T: 0 Hr, P: 0 Hrs. Per week **Total Credits : 3**

Course Objectives

The objective of the course is to prepare the students:

1. To understand the measurement system and its various components.
2. To make students aware of a various sensor in the domain of engineering field
3. To understand the automatic controls with feedback and to use it in models in various systems

Course outcomes

At the end of this course the student shall be able to:

CO1 : Understand measurement systems; apply principles of error reductions in measurement systems.

CO2 : Identify the characteristics of instruments and analyze the response of instruments to different types of inputs & Explore different transducers and sensors with their working principle.

CO3 : Understand the principles of operation of different sensors

CO4 : Analyse measurement and to use software & hardware for acquisition of data

CO5 : Understand fundamentals of control system and control system representation through Block Diagram and Signal Flow Graph

CO6 : Understand the modelling of various Physical, mechanical, electrical, hydraulic, pneumatic and thermal systems.

Syllabus

Unit-1. Measurement Systems, generalized measurement system, static and dynamic characteristics of measurement systems, errors and its types.

Unit-2. Sensors and Industrial Instrumentation Resistive-, capacitive -, inductive- piezoelectric -, Hall effect sensors and associated signal conditioning circuits; transducers for industrial instrumentation:

Unit - 3 Sensors for Displacement (linear and angular), velocity, acceleration, force, torque, vibration, pressure (including low pressure), flow (differential pressure, variable area, electromagnetic, ultrasonic, turbine and open channel flow meters) temperature (thermocouple, thermometers, RTD), thermistor, pyrometer and semiconductor); liquid level, conductivity and viscosity measurement.

Unit -4 Introduction to data acquisition, elements of data acquisition systems, A To D convertors, Signal conditioningUnit–5 Introduction of control system and concept of transfer function, system

representation through block diagram and signal flow graph, transfer function through block diagram simplification and Mason's Gain formula

Unit-6. Mathematical Modelling of Physical Systems, mechanical system, electrical system, hydraulic systems, pneumatic system, thermal systems

Text Books

1. Ernest O. Doebelin, Measurement systems Application and Design, Tata McGraw Hill Edition.
2. Nakra B.C. and Chaudhary K.K., Instrumentation, Measurement and Analysis, Tata McGraw Hill.
3. Kumar D. S., Mechanical Measurements, Kataria & Sons.
4. Mishra R.C., Pathak K., Maintenance Engineering and Management, Prentice Hall ofIndia Pvt. Ltd., 2002.
4. Ogata, Modern Control Engineering, PHI Publications.
5. Nagrath & Gopal, Control system, TMH Publications.

Reference Books

1. Alan S. Morris, Principles of Measurement and Instrumentation, Prentice Hall of India.
2. K. Sawhney, Mechanical measurement and instrumentation, Dhanpat Rai & Company.
3. Dorf, Modern Control System, Pearson Publications.
4. Kuo B.C., Automatic control system, PHI Publications.

VI Semester
Department of Mechanical Engineering

Course Code : MEP-362 **Course : Instrumentation and Control**

L: 0 Hrs, T: 0 Hr, P: 1 Hrs. Per week **Total Credits : 0.5**

Course Objectives

The objective of the course is to prepare the students:

1. To verify the characteristics of different measuring instruments and devices.
2. To use sensors for the measurement of mechanical quantities.

Course outcomes

1. Perform laboratory experiments for the measurement of quantities such as pressure, temperature, flow, load, strain, angular and linear displacement, speed, light intensity etc.
2. Identify, formulate, and solve signal conditioning problems by applying principles of different measurement system.
3. Estimate the uncertainty of an experimental result from the experimental errors associated with the data and find out the accuracy of the instruments and write the conclusions about the experiments using the obtained result.
4. Use of hardware and software for acquisition of data

The laboratory will have minimum Eight Practical based on the syllabus of MET303

Experiments based on following topics:

1. Calibration Of Pressure Gauges Using Dead Weight Pressure Gauge Tester
2. Angular Displacement Measurement Using Variable Capacitive Transducer
3. Linear Displacement Measurement Using Inductive Pick Up
4. Force Measurement Using Load Cell
5. Speed Measurement Using Inductive And Optical Transducer
6. Pressure Measurement Using Piezo-Resistive Pressure Sensor
7. Displacement Measurement Using Lvdt
8. Pressure Measurement Using Bourdon Tube 'C' Type With LVDT
9. Vibrations Measurement Using Piezo-Resistive Transducer
10. Light Intensity Measurement Using LDR
11. Torque Measurement Using Strain Gauges And Cantilever Jig
12. Strain/Force Measurement Using Strain Gauge Mounted On Cantilever Beam
13. Temperature Measurement Using Radiation Pyrometer
14. Humidity Measurement Using Capacitive Transducer For 90% R H Non Condensed
15. Measurement Of Speed Of Wind Using Digital Anemometer
16. Introduction to Sound and vibration suit with portable DAQ.

VI Semester
Department of Mechanical Engineering

Course Code : MET363 **Course : Finite Element Analysis**

L: 2 Hrs, T: 0 Hr, P: 0 Hrs. Per week **Total Credits : 02**

Course Objectives

The objective of the course is to prepare the students:

1. To solve the complex problem of mechanical engineering (Structural and Thermal) domain by finite element method.
2. To develop the computational proficiency to analyze any structure using any analysis software.

Course outcomes

At the end of this course students will be able to

1. Understand the basic concept of FEM and stress analysis.
2. Demonstrate the various approaches to find the field variable.
3. Analyze the machine elements using 1-Dimensional elements.
4. Analyze plain stress, plain strain and axi-symmetric problems by using CST elements.
5. Analyze the beam and structure subjected to free vibration.
6. Analysis of 1-D and 2-D steady state heat conduction problems.

Unit I

Fundamental concepts of FEM, Historical background, Scope of FEM in Engg. Applications, Fundamentals of stress & strain, stress & strain components, stress-strain relationship, Elastic constants, plane stress, plane strain condition, differential equation of equilibrium, compatibility equations, boundary conditions, Saint Venant's principle, sky line approach.

Unit II

Comparison of FEM with other approaches like Galerkin, Petro-Galerkin, Least square and Sub-domain method. Rayleigh-Ritz method, Principle of minimum potential energy, Basic steps in FEM, Methods for solution of simultaneous equations like Gauss elimination, Concept of discritization of body into elements, types of coordinate system degrees of freedom, bandwidth, Basic types of 1-D, 2-D & 3-D elements, displacement models, convergence requirements.

Unit III

Analysis of one-dimensional and spring element, significance of shape function, Derivation of stiffness matrix, load vector, stress and strain calculation, temperature effects. Analysis of one-dimensional subjected to torsion, Analysis of two dimensional trusses.

Unit IV

Two dimensional problems using CST (Constant Strain Triangle), elemental stiffness matrix, global stiffness matrix, stress and strain calculation. Analysis of axi-symmetric solid subjected to axi-symmetric loading using CST element. Introduction to LST.

Unit V

Finite element modeling of Beam element, derivation of stiffness matrix and load vector, boundary conditions. Introduction to dynamic analysis, formulation of mass matrix for one- dimensional bar element, free vibration analysis using one-dimensional bar element.

Unit VI

Steady state one dimensional and two dimensional heat conduction problems using I-D and triangular elements respectively. Introduction to Iso-parametric & Higher order elements. Preprocessing, solution & Post-processing stages in FEM.

Text Books

1. Timoshenko S.P., Theory of Elasticity, McGraw Hill.
2. Chandrupatla T. R. & Belegundu A. D., Introduction to Finite Elements in Engineering, PHI.
3. Alavala C.R., Finite Element Methods: Basic Concepts and Applications, PHI.

Reference Books

1. Finite Element Method- Daryl L. Logan (Cengage Learning)
2. Saeed Moaveni, Finite Element Analysis, Pearson.
3. Bhavikatti S. S., Finite Element Analysis, New Age International.

VI Semester
Department of Mechanical Engineering

Course Code : MEP363 **Course : Finite Element Analysis**

L: 0 Hrs, T: 0 Hr, P: 2 Hrs. Per week **Total Credits : 01**

Course Objectives

To develop the computational proficiency to analyze any structure using any analysis and computational software to validate the analytical results.

Course outcomes

At the end of this course students will be able to

1. Understand the concept of preprocessing, processing and processing steps in analysis.
2. Perform 1-D, 2-D and 3-D structural, modal and thermal analysis of various machine elements.
3. Develop the expertise in selecting suitable material and elements as per the application.
4. Develop the expertise in converting physical models into FE models by applying suitable boundary conditions and loading to the structure.

List of Practical

1. Introduction to finite element analysis software.
2. Finite element analysis problem of 1- dimensional bar element subjected to axial loading.
3. Finite element analysis problem of 1- dimensional bar element considering self weight.
4. Finite element analysis problem of 1- dimensional bar element subjected temperature.
5. Finite element analysis problem of 2-dimensional trusses.
6. Finite element analysis problem of plane stress condition problem using CST element.
7. Finite element analysis problem of axi-symmetric condition problem using CST element.
8. Finite element analysis of shaft/beam using beam element.
9. Finite element analysis problem of free vibration.
10. Finite element analysis problem on steady state heat conduction.
11. Matlab code generation for 1-D and 2-D problem.

Note : Students should verify the result obtained by software with algebraic method.

VI Semester
Department of Mechanical Engineering

Course Code : MEP364 **Course : Design of Machine Eléments-II**

L: 0 Hrs, T: 0 Hr, P: 2 Hrs. Per week **Total Credits : 01**

Course Objective

Students shall acquaint the practical exposure of various machine elements by designing and developing the transmission system for various applications.

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

1. Understand the basic steps and various considerations for design of machine elements.
2. Design various machine elements required to develop the complete transmission system and then after generate the geometric model to communicate for the manufacturing process.
3. Justify selection of material, geometry of machine elements, various physical and thermal properties while designing.
4. Perform the maintenance by assembling and disassembling various machine elements.

List of Experiment

01. Design of Transmission system for given application. (Design of individual components, geometric modeling and demonstration).

Note:

a. A group of 6 to 10 students will be assign a problem statement to design and develop a transmission system.

b. Problem statement consists of practical application, power at input and output shaft.

c. Student(s) will first design the various elements of the transmission system based on available transmission elements like gears, pulleys to decide the material, number of stages and type of drive.

d. After design and development of the complete transmission system, students will generate geometric models (Part drawings) and perform the analysis of critical part(s).

02. Monitoring and maintenance, assembly and disassembly of machine elements of transmission and allied systems.

Note : Resource person(s) from authorized service centers/industries will be invited to train/demonstrate the students.

Students will be taught/provided the design process of following machine elements to complete above experiments:

1. Design of Couplings:
2. Design of Friction Clutches:
3. Design of different types of Gears
4. Design of Flexible Elements (Drives)
5. Design/Selection of Bearings

Books

1. Richard G. Budynas, J Keith Nisbett, "Shigley's Mechanical Engineering Design", McGraw Hill, Ninth edition, 2011.
2. Robert L Norton, Machine design: An integrated approach, Pearson Education, Second edition, 2009.
3. V B Bhandari, Design of Machine Elements, Tata McGraw Hill Education Private Limited, Third Edition, 2012.
4. Joseph E. Shigley, Charles R. Mischke, Standard Handbook of Machine Design, McGraw- Hill, Second Edition.
5. Design Data: Data Book of Engineers PSG College-Kalaikathir Achchagam – Coimbatore

VI Semester
Department of Mechanical Engineering

Course Code : MET365-1, Elective-I **Course : Introduction to Computational Fluid Dynamics**

L: 3 Hrs., T: 0 Hrs., P: 0 Hrs., Per week **Total Credits : 03**

Course Objectives

The objective of the course is to prepare the students:

1. To learn finite difference techniques implementation in heat transfer and fluid flow.
2. To develop computational solutions to fluid flow and heat transfer problems

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Understand Conservation laws in fluid flow
2. Differentiate between FDM & FVM
3. Analyze heat conduction and convection problems
4. Formulate Pressure-Velocity coupling
5. Apply turbulence models
6. Implement CFD procedures

Syllabus

MODULE I: (7 Hrs)

Introduction to Computational Fluid Dynamics (CFD), Need for CFD, Applications of CFD, The Strategy of CFD, Eulerian and Lagrangian methods, Reynolds transport theorem, Fluid flow governing equations, Continuity, Navier-stokes and energy equation. Euler equation. Concept of Boundary layer and flow over flat plate.

MODULE II: (8 Hrs)

Boundary conditions, Elliptic, Parabolic and Hyperbolic PDEs, Grid generation, Structured and unstructured grids, Grid Convergence, Developments in Grid generation. Concept of FDM, FEM and FVM. Taylor series expansion, Finite difference equations (FDE) of 1st and 2nd Order derivatives, Truncation errors, order of accuracy. Discretization Using the Finite- Difference Method, explicit and implicit method. Application of Boundary Conditions, Assembly and solution of Discrete System.

MODULE III: (7 Hrs)

Finite Volume Mesh Generations Discretization Using Finite-Volume Method, Finite Volume Method for Diffusion problems Finite Volume Method for Convection-Diffusion Problems, Central Differencing scheme, The upwind differencing scheme. The Crank– Nicholson MethodMODULE IV: (7 Hrs)

TDMA, Space Marching, The pressure correction formula, Pressure-velocity coupling in steady flows and algorithms, staggered grids, Stability analysis, FEM for 1 D and 2D PDEs

MODULE V: (7 Hrs)

Concept of Various Turbulence models. Time averaged Navier-Stokes Equation, mixing length model, RANS equation, k-epsilon model Concept of Compressible and incompressible fluid flow, isentropic flow and normal shock.

MODULE VI: (8 Hrs)

Concept of multi phase fluid flow. Understanding and implementing commercial CFD software. Applications of Sc Flow software.

Text Book

1. Versteeg H. K. and Malalasekera W., An Introduction to Computational Fluid Dynamics (The finite volume Method), Prentice Hall, Longman Scientific Technical, 0-582-21884-5.
2. John D. Anderson Jr., Computational Fluid Dynamics (The basics with Applications), McGraw Hill, ISBN 0-07-113210-4.
3. Niyogi P., Laha M. K., Chakrabarty S.K., Introduction to Computational Fluid Dynamics, Pearson Education, India.

Reference Books

1. Chung T. J., Computational Fluid Dynamics, CAMBRIDGE UNIVERSITY PRESS, ISBN 0 521 59416 2 hardback.
2. Training material provided by TATA Technologies Ltd. (CIIIT).

VI Semester
Department of Mechanical Engineering

Course Code : MEP365-1,Elective-I **Course : Introduction to Computational Fluid Dynamics**

L: 0 Hrs., T: 0 Hrs., P: 1 Hrs., Per week **Total Credits : 0.5**

Course Objectives

The objective of the course is to prepare the students:

1. To simulate fluid flow and heat transfer and validate the results
2. To develop codes and macros for some engineering problems

Course Outcomes

The expected learning outcome is that the students will be able to: After studying the course, the student will be able to:

1. Understand the CFD procedure Pre-processing, Processing, Post-processing
2. Build the geometric and CFD model with grid generation and Boundary conditions
3. select appropriate solve and solution schemes
4. Interpret the results and carry out general post processing
5. Develop Algorithms, Flow charts and codes
6. Apply CFD to Fluid flow and heat transfer applications

List of Experiments

1. Simulate and solve two problems, each 2-d and 3-d steady and unsteady flows using any commercial CFD package like Ansys-FLUENT, scFLOW, STAR CCM, FLUIDYNE, Ansys-CFX, etc.
2. Write MATLAB, openfoam etc. codes for, at least one each, 1-d and 2-d steady conduction with and without source and do the post processing to verify with analytical results
3. Write MATLAB, openfoam etc. codes, at least one, for steady, 2-d conduction-advection problems and do the post processing to verify with analytical results

VI Semester
Department of Mechanical Engineering

Course Code : MET365-2, Elective-I **Course : Internal Combustion Engines**

L: 3Hrs., T: 0 Hrs., P: 0 Hrs., Per week **Total Credits : 03**

Course Objectives

The objective of this course is

1. To give comprehensive insights into the operations of different types of engines and its subsystems.
2. To present the internal and external parameters which govern engine performance, emission formation and methods to control them.

Course Outcomes

After completion of the course the student would be able to

1. Classify the types of engines and explain the working of engine, its cooling and lubrication system.
2. Distinguish between different types of fuels and explain fuel supply system for a given type of engine.
3. Describe the process of combustion in S.I and C.I engine and illustrate the effect of flame velocity, ignition timing, ignition delay, etc. on engine performance.
4. Express the causes of pollution formation in I.C engines and discuss various measures to control the same.
5. Interpret the effects of various performance parameters on engine performance and evaluate engine parameters.
6. Illustrate the increasing importance of alternate and electric powertrain and recent technologies.

Syllabus

UNIT - I

Introduction and Historical Perspective, Engine classifications, Engines types and their operation, Engine Operating & Working Cycle, structural components and its material. Engine friction, Frictional losses, blow by losses, pumping loss, lubrication systems, Factors affecting mechanical friction, Engine Cooling System.

UNIT - II

AUTOMOTIVE FUELS: Engine fuels characteristics, C.I. Engine fuels characteristics Rating of engine fuels, I.C. engine fuels - petrol, diesel, CNG, LPG, Alcohols, Vegetable oils. Fuel Supply System in S.I. Engine; Carburetors, SPFI, MPFI, GDI, Fuel injection pump:reciprocating & rotary, fuel injector, High pressure D.I. systems, fuel distribution systems, CRDI.

UNIT - III

Combustion in S.I. and C.I engines: Valve timing diagram combustion stages, flame propagation, cyclic variations in combustion, abnormal combustion, knock fundamentals, turbo charging, supercharging, turbocharging and scavenging in engines, ignition fundamentals, conventional ignition system, combustion chamber designs.

UNIT –IV

Automotive Emissions and its effects, Emission Norms, Pollutant formation: Nitrogen oxides Kinetics of NO formation, formation of NO2, NOx formation in S. I. Engines &C. I. Engine Carbon monoxide and unburned hydrocarbon emissions in S.I. and C.I. engines, EGR Particulate emissions, measurement technique, Catalytic converters, particulate traps, Specific emission and emission Index. On Board Diagnosis.

UNIT - V

Engine Design and Operating Parameters, Important engine characteristics, Geometrical properties of Reciprocating engines, Brake Torque & Power, Indicated work per cycle, Mechanical efficiency, Mean effective pressure, Specific fuel consumption and efficiency, Air/Fuel and Fuel/Air ratios, Volumetric efficiency, Engine specific weight and specific volume, Correction factors for power & efficiency, Relationship between different performance parameters, Measurement of friction power indicated power, Brake power, Fuel consumption, Air consumption, Performance parameters and characteristics: Engine Power, Engine efficiencies, Engine performance characteristics, Variables affecting performance characteristics.

UNIT- VI

Recent Advancments: Engine Management System, Alternate Powertrain, Electric and Hybrid Powertrain.

Text Book

1. Ganesan V., Internal Combustion Engines, Tata McGraw Hill Education.
2. Mathur M. C., Sharma R.D., Internal Combustion Engines, Dhanat Rai Publications.
3. John B. Heywood, Internal Combustion Engine Fundamentals, Tata McGraw Hill Education.

Reference Books

1. Domkundwar V. M., Internal Combustion Engines, Dhanpat Rai Publications.
2. Edward F. Obert, Internal Combustion Engines and Air pollution, Intex Education Publication.
3. Shyam K Agrawal, Internal Combustion Engines, New Age International Publishers.

VI Semester (Elective - I)
Department of Mechanical Engineering

Course Code : MEP 365-2, Elective-I **Course : Internal Combustion Engines**

L: 0Hrs., T: 0 Hrs., P: 1 Hrs., Per week **Total Credits : 0.5**

Course Objectives

The objectives of this course is to give practical insight on constructional details engine subsystems and performance evaluation and engine testing.

Course Outcomes

After completion of this course the students will be able to

1. Demonstrate the construction, working details of I.C engine components
2. Estimate the cylinder pressure variation and heat balance sheet.
3. Analyze the effects of various parameters on engine performance.
4. Examine the causes of engine emission, its measurement and control.

List of Experiments

1. Introduction to components and working of Internal Combustion Engine
2. Estimation of P-0 curve for S. I and C. I Engine using computerised engine test rig.
3. Evaluation of Heat Balance Sheet for S.I and C.I engine on computerised engine test rig.
4. Performance evaluation of variable compression engine.
5. Estimate the effects of Bio-fuel on performance of I.C Engine .
6. Emission measurement of I.C Engine using 3-Way gas analyzer.
7. Study of Modern Engine Management system.
8. Demonstration of modern twin turbo charged, BMW diesel engine.

VI Semester
Department of Mechanical Engineering

Course Code : MET365-3, Elective - I | **Course : Computer Graphics**

L: 3 Hrs, T: 0 Hr, P: 0 Hrs. Per week | **Total Credits : 03**

Course Objectives

The student should be able to:

Learn and apply the knowledge of computer graphics to manipulate various graphical entities.

Course outcomes

At the end of this course students will able to:

1. Understand the basics and need of computer graphics.
2. Develop the programs to generate the line and circle using DDA and Bresenham's algorithms.
3. Apply the concept of 2-D transformation to manipulate a geometrical entity.
4. Apply the concept of 3-D transformation to manipulate a geometrical entity.
5. Understand various techniques to generate the geometrical model.
6. Understand mathematical representation of geometrical entities like curves and surfaces.

Unit I

Introduction to computer graphics and its application, CAD Softwares modules (Operating System, Graphics, Applications, Programming, Communication). Product life cycle, Various techniques to generate the images, Rasterization Principle, Rasterization of line, frame buffer, N- bit plane buffers, simple color frame buffer.

Unit II

Scan conversion: Scan conversion of a point, scan conversion of a line (DDA and Bresenham's algorithm), Scan Conversion of circle and ellipse, Region feeling

Unit III

Two dimensional geometric and co-ordinate transformations like scaling, translation, rotation, reflection, and shear. Concept of homogeneous representation and concatenated transformations. Inverse transformations. (Enumeration of entity on graph paper)

Unit IV

Three dimensional geometric and co-ordinate transformation like scaling, translation, rotation and reflection. Projection transformation: Parallel projection, Perspective projection

Unit V

Geometric Modeling: Introduction to surfaces, surface of revolution. Wire frame modeling, solid modeling of basic entities like box, cone, cylinder. CSG & B-rep technique.

Unit VI

Mathematical representation of 2-D entities and Surface entities, Bezier Curve (for 4 Control points).

Text Books

1. David F. Rogers, Procedural elements for computer graphics, Mc-Graw Hill.
2. Donald Hearn and M. Pauline Baker, Computer Graphics 'C' Version, Second Edition, Pearson publication.
3. David Rogers and J. Alan Adams, Mathematical elements for computer graphics, Tata Mcgraw Hill Education Private Limited.

Reference Books

1. Foley, Vandam, Feiner and Huges, Computer graphics principles and practice in C, Pearson.
2. Neeta Jain, Computer Graphics, Vikas publications.
3. Newman and Sproul, Principles of interactive computer graphics.

VI Semester
Department of Mechanical Engineering

Course Code : MEP365-3, Elective - I **Course : Computer Graphics**

L: 0 Hrs, T: 0 Hr, P: 1 Hrs. Per week **Total Credits : 0.5**

Course objective

The student should be able to: Learn programming skills to create and manipulate various geometrical entities by using the concepts of computer graphics.

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Understand the software and hardware required for computer graphics.
2. Develop algorithms and C-programs to generate various graphical entities.
3. Develop algorithms and C-programs based on 2-D and 3-D transformations.

List of Experiments

1. Study of Computer Aided Design (CAD) softwares.
2. C-Program of DDA line algorithm.
3. C-program of Bresenham's line algorithm
4. C-program of Bresenham's circle algorithm
5. C-program of Bresenham's ellipse algorithm
6. Generation of at least two simple solid models showing geometric properties using any CAD software.
7. C- program on Translation transformation
8. C-program on rotation transformation
9. C-program on scaling transformation
10. C-program on reflection/mirroring transformation
11. C-program on composite transformation

VI Semester
Department of Mechanical Engineering

Course Code : MET365-4, Elective - I **Course : Synthesis of Mechanisms**

L: 3 Hrs. T: 0 Hrs. P: 0 Hrs. Per week **Total Credits : 03**

Course Objectives

1. Provide theoretical background for basic and advanced kinematics and synthesis of mechanisms to achieve desired motion.
2. Provide an opportunity for students to use theory and application tools through a major mechanism design project.

Course Outcomes

The expected learning outcome is that, the students will have

1. Ability to understand basics of mechanisms
2. Ability to understand synthesis of mechanisms for motion generation
3. Ability to understand synthesis of mechanisms for function generation
4. Ability to understand synthesis of mechanisms for path generation
5. Ability to understand synthesis for infinitesimally separated positions
6. Ability to understand various spatial Mechanisms and applications

Syllabus

UNIT-I

Kinematics fundamentals: Links, pairs, kinematic chains, types of mechanism, mobility of mechanisms, inversions, Degree of freedom, class-I, class-II chain, Harding's notation, Grashof criterion, Grubler's criterion.

UNIT-II

Synthesis for motion generation: concept of pole, two &three position generation synthesis, concept of dyad, pole triangle, Relationship between moving & fixed pivots, Four position generation, opposite pole quadrilateral, center point &circle point curve, Burmester's point. Matrix method for position generation problem, rotation matrix, displacement matrix

UNIT-III

Synthesis for function generation: co-ordination of input-output link motion, relative pole technique, inversion technique, overlay technique, graphical synthesis of quick return mechanisms for optimum transmission angle. Types of errors, accuracy points, chebyshev's spacing, Frudenstein's equation.

UNIT-IV

Synthesis for path generation: synthesis for path generation with and without prescribed timing using graphical method. Coupler curves, cognate linkages, Robert's law of cognate linkages.

Complex number method for path generation problem 3 precision points

UNIT-V

Synthesis for infinitesimally separated position, concept of polode and centroid, Euler's savery equation, inflection circle, Bobbilier and Hartman's construction.

UNIT-VI

Optimization techniques in synthesis.

Spatial mechanisms, kinematics of spatial mechanisms.

Text Books

1. Jr. Hall, Allen S., Kinematics and Linkage Design,Prentice Hall Engineering Science series, 1961
2. Sandor G.N. & Erdman A.G., Advanced Mechanism Design: Analysis and synthesis Volume-II, Prentice-Hall Englewood.
3. Uicker and Shigley, Theory of Machines and Mechanisms, Tata McGraw Hill.
4. Rattan S. S., Theory of Machines, Tata McGraw Hill.

Reference Books

1. Tao D.C, Applied Linkage Synthesis.
2. Wilson & Sadler, Kinematics & Dynamics of Machinery, Harper Collins Publishers.
3. Sue C.H. & Radchiffe C.W., Kinematics and Mechanism Design, John Wiley & Sons.
4. Norton R. L., Kinematics & Dynamics of Machinery, Tata McGraw Hill.
5. Rao J.S. & DukkiPati R.V., Mechanism and Machine Theory, New Age International.

VI Semester
Department of Mechanical Engineering

Course Code : MEP365-4, Elective-I **Course : Synthesis of Mechanisms**

L: 0 Hrs. T: 0 Hrs. P: 1 Hrs. Per week **Total Credits : 0.5**

Course Objectives

1. Provide an opportunity for students to use theory and application tools through a major mechanism design project

Course Outcomes

The expected learning outcome is that, the students will have practical approach for synthesis of mechanisms

1. For motion generation
2. For function generation
3. For path generation
4. Kinematics of spatial Mechanisms

Syllabus

1. Two position and three position motion generation problems
2. Two position and three position function generation problems
3. Path generation problems and cognate linkages
4. Problem on kinematics of spatial mechanisms

VI Semester
Department of Mechanical Engineering

Course Code : MET365-5 Elective-I **Course : Soft Computing Techniques in Mechanical Engineering**

L: 3 Hrs, T: 0 Hr, P: 0 Hrs. Per week **Total Credits : 03**

Course Objectives

1. Develop the skills to gain a basic understanding of neural network theory and fuzzy logic theory.
2. Introduce students to artificial neural networks and fuzzy theory from an engineering perspective

Course Outcomes

Upon completion of the course, the student are expected to

1. Comprehend the fuzzy logic and the concept of fuzziness involved in various systems and fuzzy set theory.
2. Understand the concepts of fuzzy sets, knowledge representation using fuzzy rules, approximate reasoning, fuzzy inference systems, and fuzzy logic
3. To understand the fundamental theory and concepts of neural networks, Identify different neural network architectures, algorithms, applications and their limitations
4. Understand appropriate learning rules for each of the architectures and learn several neural network paradigms and its applications

Syllabus

1. Introduction to Soft Computing

Soft Computing: Introduction to soft computing, soft computing vs. hard computing, various types of soft computing techniques, applications of soft computing

Introduction, Fuzzy Computing, Neural Computing, Genetic Algorithms, Associative Memory, Adaptive Resonance Theory, Applications

2. Fuzzy Logic

Fuzzy Logic: Fuzzy set theory, Fuzzy set versus crisp set, Crisp relation & fuzzy relations, Fuzzy systems: crisp logic, fuzzy logic, introduction & features of membership functions.Fuzzy rule base system : Fuzzy propositions, formation, decomposition & aggregation of fuzzy Rules, fuzzy reasoning, fuzzy inference systems, fuzzy decision making & Applications of fuzzy logic

3. Fundamentals of Neural Network

Introduction, Model of Artificial Neuron, Architectures, Learning methods, Taxonomy of NN Systems, Single layer NN System, Applications

Structure and Function of a single neuron: Biological neuron, artificial neuron, definition of ANN, Taxonomy of neural net. Difference b/w ANN and human brain, characteristic and applications of ANN, single layer network.

4. Fundamental of Genetic Algorithms

Genetic algorithm: Fundamental, basic concepts, working principle, encoding, fitness function, reproduction, Genetic modeling: Inheritance operator, cross over, inversion & deletion, mutation operator, Bitwise operator ,Generational Cycle, Convergence of GA, Applications & advances in GA, Differences & similarities between GA & other traditional methods

Text Books

1. Simon Haykin, "ArtificialNeutral Networks".
2. Yegna Narayanan, "Artificial Neural Networks".
3. Timothy J. Ross, " Fuzzy Logic with Engineering Applications"
4. S.N.Sivanandam, S.N Deepa, "Principles of Soft Computing"

Reference Books

1. Bart Kosko, "Neural Network and Fuzzy Systems: A Dynamic System Approach to Machine" Prentice-Hall 19982
2. L. Fausett, "Fundamentals of Neural Networks: Architectures, Algorithms, and Applications", Prentice-Hall, 19943.
3. Jack M. Zurada, "Introduction to Artificial Neural Systems",PWS Publishing Co., Boston, 2002.

VI Semester
Department of Mechanical Engineering

Course Code : MEP365-5 Elective -I **Course Name : Soft Computing Techniques in Mechanical Engineering**

L: 0 Hrs, T: 0 Hr, P: 01 Hrs. Per week **Total Credits : 0.5**

Course Objectives

Appreciate the importance of optimizations and its use in computer engineering fields and other domains.

Course Outcomes

CO1: Understand components of Soft Computing and differentiate between hard and soft computing.

CO2: Understand the difference between learning and programming and explore practical applications of Neural Networks (NN).

CO3: To analyse and appreciate the applications which can use fuzzy logic.

CO4: Understand the basics of genetic algorithm, use of GA operators and its applications.

SOFTWARE REQUIREMENT:

1. Turbo C++ IDE (TurboC3)
2. Borland Turbo C++ (Version 4.5)
3. Python 3.4.3
4. MatLab / SciLab

List of Experiments:

1. Implementation of Fuzzy Operations.
2. Implementation of Fuzzy Relations (Max-min Composition)
3. Implementation of Fuzzy Controller (Washing Machine)
4. Implementation of Simple Neural Network (McCulloh-Pitts model)
5. Implementation of Supervised Learning Algorithm
6. Implementation of Unsupervised Learning Algorithm
7. Implementation of Simple Genetic Application
8. MatLab Library and Codes
9. Study of research paper on Soft Computing.
10. Simulation in MatLab of Mechanical Application

VI Semester
Department of Mechanical Engineering

Course Code : MET365-6 Elective I **Course : Additive Manufacturing**

L: 3 Hrs, T: 0 Hr, P: 0 Hrs. Per week **Total Credits : 03**

Course Objectives

The objective of the course is to prepare the students:

1. To exploit technology used in additive manufacturing.
2. To understand the importance of additive manufacturing in the advanced manufacturing process.
3. To acquire knowledge, techniques and skills to select relevant additive manufacturing process
4. To explore the potential of additive manufacturing in different industrial sectors.
5. To apply 3D printing technology for additive manufacturing.

Course Outcomes

After the completion of this course, students will be:

CO1 Able to define the various process used in Additive Manufacturing

CO2 Able to analyse and select suitable process of materials and Problems used in Liquid based AM

CO3 Able to analyse and select suitable process and materials and Problems used in Solid based AM.

CO4 Able to analyse and select suitable process and materials and Problems used in Powder based AM

CO5 Able to apply knowledge of additive manufacturing for various real-life applications CO6 Able to apply technique of CAD and reverse engineering for geometry transformation in AM

UNIT –I Introduction:

Prototyping fundamentals: Need for time compression in product development, Need for Additive Manufacturing, Historical development, Fundamentals of Additive Manufacturing, AM Process Chain, Advantages and Limitations of AM, Commonly used Terms, Classification of AM process, Fundamental Automated Processes: Distinction between AM and CNC, other related technologies.

UNIT – II Liquid-based AM Systems:

Stereo lithography Apparatus (SLA): Models and specifications, Process, working principle, photopolymers, photo polymerization, Layering technology, laser and laser scanning, Applications, Advantages and Disadvantages, Case studies. Solid ground curing (SGC): Models and specifications, Process, working principle, Applications, Advantages andDisadvantages, Case studies. Polyjet: Process, Principle, working principle, Applications, Advantages and Disadvantages, Case studies. Microfabrication.

UNIT – III Solid-based AM Systems:

Laminated Object Manufacturing (LOM): Models and specifications, Process, working principle, Applications, Advantages and Disadvantages, Case studies. Fused Deposition Modeling (FDM): Models and specifications, Process, working principle, Applications, Advantages and Disadvantages, Case studies. Multi-Jet Modelling (MJM): Models and specifications, Process, working principle, Applications, Advantages and Disadvantages, Case studies.

UNIT – IV Powder Based AM Systems:

Selective laser sintering (SLS): Models and specifications, Process, working principle, Applications, Advantages and Disadvantages, Case studies. Three dimensional Printing (3DP): Models and specifications, Process, working principle, Applications, Advantages and Disadvantages, Case studies. Laser Engineered Net Shaping (LENS): Models and specifications, Process, working principle, Applications, Advantages and Disadvantages, Case studies. Electron Beam Melting (EBM): Models and specifications, Process, working principle, Applications, Advantages and Disadvantages, Case studies

UNIT V Rapid Tooling and Medical - BIO-Additive Manufacturing

Rapid Tooling: Introduction to Rapid Tooling (RT), Conventional Tooling Vs RT, Need for RT. Rapid Tooling Classification: Indirect Rapid Tooling Methods: Arc Spray Metal Deposition, Investment Casting, Sand Casting, 3D Keltool process. Direct Rapid Tooling: Direct AIM, LOM Tools, DTM Rapid Tool Process, EOS Direct Tool Process and Direct Metal Tooling using 3DP.

Customized implants and prosthesis: Design and production. Bio-Additive Manufacturing- Computer, Aided Tissue Engineering (CATE) – Case studies

UNIT – VI AM Data Formats:

Reengineering for Digital Representation, STL Format, STL File Problems, Consequence of Building Valid and Invalid Tessellated Models, STL file Repairs: Generic Solution, Other Translators, Newly Proposed Formats. Mesh Refining by Sub division Techniques.

AM Software's: Need for AM software, Features of various AM software's like Magics, Mimics, Solid View, View Expert, 3 D View, Velocity 2, Rhino, STL View 3 Data Expert and 3 D doctor, SurgiGuide, 3-matic, Simplant, MeshLab.

Text Books

1. Chua C.K., Leong K.F. and LIM C.S Rapid prototyping: Principles and Applications -, World Scientific publications , Third Edition, 2010.
2. D.T. Pham and S.S. Dimov Rapid Manufacturing –, Springer , 2001
3. Terry Wohlers Wholers Report 2000 –, Wohlers Associates, 2000
4. Frank W.Liou Rapid Prototyping & Engineering Applications, CRC Press, Taylor &Francis Group, 2011.
5. Gibson, I, Rosen, D W., and Stucker,B., Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing,Springer, 2010
6. Chee Kai Chua, Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications: Fourth Edition of Rapid Prototyping, World Scientific Publishers, 2014

Reference Books

1. Liou L.W. and Liou F.W., "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press, 2007
2. Kamrani A.K. and Nasr E.A., "Rapid Prototyping: Theory and practice", Springer, 2006
3. Mahamood R.M., Laser Metal Deposition Process of Metals, Alloys, and Composite Materials, Engineering Materials and Processes, Springer International Publishing AG 2018
4. Ehsan Toyserkani, Amir Khajepour, Stephen F. Corbin, "Laser Cladding", CRC Press, 2004

VI Semester
Department of Mechanical Engineering

Course Code : MEP365-6 (Elective-I) **Course : Additive Manufacturing**

L: 0 Hrs. T: 0 Hrs. P: 1 Hrs. Per week **Total Credits : 0.5**

Course Objectives

To acquire knowledge, techniques and skills to select, design, analyse and conduction of relevant additive manufacturing process

Course Outcomes

The expected learning outcome is that the students will be able to:

CO1 apply technique of CAD and reverse engineering for geometry transformation in AM

CO2 analyse and select suitable processes and materials used in Additive Manufacturing.

CO3 identify, analyse and solve problems related to Additive Manufacturing.

CO4 apply knowledge of additive manufacturing for various real-life applications

List of Experiments

Exp. 1. Introduction to Solid Modeling & CREO 2.0, / Cativa V6 Packages

Exp. 2. Modeling Creative Designs in CAD Software.

Exp. 3. Assembling Creative Designs in CAD Software

Exp. 4. Generating STL files from the CAD Models & Working on STL files with Open Source Software.

Exp. 5. Simulation Processing the CAD data (Selection of Orientation, Supports generation, Slicing, Tool path generation)

Exp. 6. Working on Process Parameters of CAD (stl) file for FDM

Exp. 7. Fabricating the physical part on FDM (Ultimakers extended)

Exp. 8. Removing the supports & post processing (cleaning the surfaces)

Exp. 9. Demonstrating Creative Working Models

Exp. 10. Converting CT/MRI scan data into STL file using 3D Doctor Software (Demo)

Exp. 11. Case Study

VI Semester
Department of Mechanical Engineering

Course Code : MET 365-7, Elective-I **Course : Mechatronic Systems**

L: 3 Hrs, T: 0 Hr, P: 0 Hrs. Per week **Total Credits : 03**

Course Objectives

To prepare students for

1. Understanding the need and rewards of amalgamation of Mechanical Engineering with Electronics, Computer Science and Control engineering.
2. Facing the challenges of the ongoing fourth industrial revolution with confidence.

Course outcomes

The expected learning outcome is that the students will be able to:

1. Understand and appreciate the synergistic combination of Mechanical Engineering with other branches of engineering.
2. Analyze the major components i.e. sensors, actuators and controllers of any Mechatronic system.
3. Explain construction and working of industrial and non- industrial Mechatronic system.
4. Explore a wide range of technologies (including Modeling and simulation) to provide the most economic, elegant and appropriate solution for the problem.
5. Demonstrate desire to remain abreast with the fast-changing technology in all walks of life.

Unit – I: INTRODUCTION

Origin and evolution, Role in industrial automation, Role in non-industrial/office automation, Multidisciplinary nature, Electrical components and electronic devices, Basic solid-state components and devices.

Unit – II: SENSORS AND TRANSDUCERS

Performance Terminology, Sensors for motion, force and torque. Various transducers- Inductive, Capacitive, Pyroelectric, Piezoelectric, Ionisation, Photoelectric.

MEMS and Microsystems: Introduction, working principle, Materials for MEMS and Microsystems, Introduction to micro-manufacturing and Micro system design.

Unit – III: ACTUATORS

Elements of electromechanical energy conversion, DC & AC motors, Different types of stepper motors, hold on torques and position control of stepper motors. Starting, inversion and control of electrical drives, coupling of mechanical loads to DC and AC electrical drives. Pneumatic and Hydraulic systems, Process control valves, Rotary actuators, Mechanical Actuation systems. Piezoelectric actuators.

Unit – IV: SIGNALS AND CONTROLLERS

Signal Conditioning, Amplification, Protection, Filtering, Bridge Circuits, Comparator, Digital signals, Introduction to digital system Processing, Pulse Modulation. Data Acquisition and Controlling, Microcontrollers and PLCs, direction and speed control of electric motors, PID controls. Introduction to Arduino and Raspberry pi.

Unit – V: MODELING AND SIMULATION

Modeling and simulation of physical systems- Mechanical, Electrical, Fluid and Thermal systems. Virtual Instrumentation and Computer Monitoring and control, modeling of the sensors, modeling of the Actuators. Techniques of interfacing mechanical devices with computer hardware and development of software for driving them (Computer Integration of Electro-Mechanical System)

Unit–VI: APPLIED MECHATRONICS

Case studies in: Mechatronics in Home appliances, Medical Devices, Defense, Automobiles and office automation. Industrial Automation. Design for manufacturing. Future of Mechatronics and its relation to Industry 4.0

Text Books

1. Mechatronics System Design, Shetty, D. and Kolk, R. A., Cengage Learning India Pvt. Ltd., Delhi
2. Mechatronics: A Multidisciplinary Approach, Bolton, W., 4 Ed., Pearson Education
3. Mechatronics: Principles, Concepts and Applications, Mahalik N.P., Tata McGraw Hill

Reference Books

1. Understanding Electro-Mechanical Engineering: an Introduction to Mechatronics, Kamm, PHI
2. Introduction to Mechatronics and Measurement Systems, David Alciators& Michael B. Histand, Tata McGraw Hill, India , 2001.
3. Mechatronics, HMT, Tata McGraw Hill, India.

VI Semester
Department of Mechanical Engineering

Course Code : MEP 365-7, Elective-I | **Course : Mechatronics Systems Lab**

L: 0 Hrs, T: 0 Hr, P: 1 Hrs. Per week | **Total Credits : 0.5**

Course Objectives

To make students capable of exploring various components of surrounding Mechatronic systems with understanding of the basic elements in the laboratory.

Course outcomes

1. The students will be able to verify the characteristics of temperature and kinematic sensors.
2. The students will be able to select and use the actuators for Mechatronic Systems.
3. The students will be able to demonstrate controlling command and their effects on systems.
4. The students will be able to describe Mechatronics in daily use systems like smart phone.

Experiments based on following topics:

- Components of Mechatronics systems
- Sensors for Temperature, displacement Encoders)
- Signal Conditioning techniques
- Electric Actuation- Interfacing and Types of Motors
- Pneumatic and Hydraulic Actuators
- Controllers like LC and Arduino, Raspberry Pi.
- Explorations on systems like- Smart phone/ BMW Steptronic Engine/rbiting Satellite.

VI Semester
Department of Mechanical Engineering

Course Code: MET366-1, Elective-II **Course : Advanced Manufacturing Techniques**

L: 3 Hrs, T: 0 Hr, P: 0 Hrs. Per week **Total Credits : 03**

Course Objectives

The objective of the course is to prepare students :

1. The understand the processing of plastic, glass, ceramics and composite materials.
2. To understand the machining principles and processes in manufacturing precision components that uses the non conventional and micromaching process.

Course outcomes

The expected learning outcome is that the students will be able to :

1. Describe working principles of different plastic processing machines.
2. Explain different forms of glass and principle of processing glass and ceramics.
3. Illustrate different joining processes, their working principles and applications.
4. Elucidate Unconventional Machining Method, their working principle and applications.
5. Understand micro machining and micro fabrication their principle of operations and applications in micro parts manufacturing such as electronic chip.
6. Explain rapid prototyping, its types, their working principle and applications.

Unit – I

Forming and shaping of plastic and composite materials: extrusion, injection molding, blow, rotational, thermoforming, hydroforming. Processing of elastomers, reinforced plastics, Metal matrix composites, ceramic matrix composites.

Unit – II

Processing of ceramics, glass and superconductors: shaping ceramics, forming and shaping glass, techniques for strengthening and treating glass, design consideration for ceramics and glasses, processing of superconductors.

Unit – III:

Unconventional joining processes: TIG, MIG, Atomic hydrogen, GMAW, Electro slag, EBW, LBW, Thermit, Plasma Arc.

Unit – IV:

Unconventional Machining Processes: Characteristics, Operation, applications, Limitation and selection of process parameters of the following processes: Abrasive water jet machining, AJM, USM, EDM, LBM (analytical treatment), ECM, ECG, Wire EDM.

Unit – V:

Micromachining, Nanofabrication: Principles, MRR, tooling, material, machine selection, processes, applications, advantages, limitations.

Unit – VI:

Rapid Prototyping operations: subtractive and additive processes, FDM, Stereo lithography, Selective laser sintering, 3D printing, Laminated object manufacturing, Rapid tooling, applications, advantages, limitations.

Text Books

1. Sharma P.C., Production Technology, S. Chand and company Ltd, New Delhi.
2. Pandey and Shan, Modern Machining Processes, Tata McGraw-Hill Education.
3. Ghosh A. & Mallik A., Manufacturing Science, Affiliated East-West press pvt.ltd.

Reference Books

1. Kalpakjian S. and Schmid S.R., Manufacturing Engineering Technology,Pearson.
2. Ian Gibson, David W. Rosen, Brent Stucker, Additive Manufacturing Technologies.
3. Hod Lipson, Melba Kurman, Wiley, Fabricated: The New World of 3D Printing by India pvt ltd.

VI Semester
Department of Mechanical Engineering

Course Code : MET366-2, Elective-II **Course : Industrial Fluid Power**

L: 3 Hrs., T: 0 Hrs., P: 0 Hrs.,Per week **Total Credits : 03**

Course Objectives

1. To teach the students various types of hydraulic fluids,seals,actuators and control valves used in fluid power systems.
2. To enable the students to read and design various industrial hydraulic circuits. 3.To understand the working of various components used in pneumatic systems.

Course Outcomes

1. Identify the hydraulic fluids, their properties and various seals used in fluid power systems with their applications.
2. Understand the construction and working of various types of hydraulic accumulators, intensifiers and valves.
3. Understand the various methods of actuation for Direction Control valves and Flow Control valves.
4. Compute the pressure drop and design parameters for hydraulic piping and actuators.
5. Design a hydraulic circuit for a given application.
6. Understand the various components, working and applications of pneumatic systems.

Syllabus

UNIT I

Fluid Power Systems : Components, advantages, applications in the field of M/c tools, material handling, hydraulic presses, mobile & stationary machines, clamping &indexing devices etc.

Transmission of power at static & dynamic states. Types of Hydraulic fluids like petroleum based, synthetic & water based. Properties of fluids, Selection of fluids, additives, effect of temperature & pressure on hydraulic fluids. Seals, sealing materials, selection of seals, Filters strainers, sources of contamination of fluid & its control.

UNIT-II

Accumulators & Intensifiers : Types & functions of accumulators, Intensifiers, applications, selection & design procedure. CONTROL OF FLUID POWER: Necessity of pressure control directional control, Flow control valves, Principle of pressure control valves, direct operated, pilot operated, Relief valves pressure reducing valve, sequence valve & methods of actuation of valves.

UNIT-III

Flow Control Valves : Principle of operation, pressure compensated, temp. Compensated flow control valves, meter in & meter out flow control circuits, bleed off Circuits. DIRECTION CONTROL VALVES: Check valves, types of D.C.Valves: Two way two Position, four way three position, four way two position valves, open center, close center Tandem center valves, method of actuation of valves, manually operated solenoid Operated, pilot operated etc.

UNIT-IV

Actuators: Linear & Rotary actuators, Hydraulic motors, - Types, vane, gear Piston, radial piston. Calculations of piston velocity thrust under static & dynamic applications. Design Consideration for cylinders. Hoses & Pipes: Types, Materials, pressure drop in hoses/pipes. Hydraulic piping connections.

UNIT-V

Design Of Hydraulic Circuits : Circuit illustrating use of pressure reducing valves, sequencing valves, counterbalance Valves, unloading valves with the use of electrical controls, accumulators etc. Maintenance, troubleshooting & safety precautions of Hydraulic Circuits. Methods of control of acceleration

UNIT-VI

Pneumatics : Introduction to pneumatic power sources, e.g. reciprocating & rotary Compressors, roots- blower etc. Comparison of pneumatics with Hydraulic power Transmission. Air preparation units, filter, regulators & lubricators. Actuators, linear Single & double acting rotary actuators, air motors, pressure regulating valves. Directional control valves two way, three way & four way valves, solenoid operated, Push button; & lever control valves. Flow control valves. Check valves methods of Actuation, mechanical, pneumatic & electrical etc. Pneumatic circuits for industrial applications & automation. e.g. Feeding clamping, Indexing, picking & placing etc.

Text Books

1. Sahashtrabudhe N.V., Introduction to Fluid Power, Nirali Prakashan Pune.
2. Pipenger J.J., Industrial Hydraulics, McGraw Hill Co.
3. Mujumdar S.R., Pneumatics circuits.

Reference Books

1. Pinches, Industrial Fluid Power, Prentice Hall.
2. Manuals on Industrial Hydraulics, Vickers
3. Stewart H.L., Hydraulics & Pneumatics, Industrial Press.
4. Fluid Power Design Handbook, Yeaple.

VI Semester
Department of Mechanical Engineering

Course Code : MET366-3, Elective-II **Course : Automobile Engineering**

L: 3 Hrs., T: 0 Hrs., P: 0 Hrs., Per week **Total Credits : 03**

Course Objective

1. To provide comprehensive insight of systems and subsystems that constitute the modern automobile and the latest trends.
2. To expose the factors which affect the performance of various automotive subsystems and their suitability for different applications.

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Recognize the fundamentals and applications of various types of automobiles, and tyres.
2. Illustrate the importance and working of transmission components and evaluate the torque transmission capacity and gear ratios.
3. Explore components and working of braking, steering and suspension system and indicate their effect on vehicle handling and stability.
4. Relate the effect of aerodynamics on ground vehicles and justify the use of wings, diffuser and spoilers on automobiles.
5. Demonstrate the importance and functioning of various electrical and electronic components and identify the need of active and passive safety in automobiles.
6. Outline the recent trends and technologies in automobiles and relate the importance of electric vehicles.

Syllabus

UNIT – I

Automobile history and development, Chassis, articulated and rigid vehicles and vehicles layout. Vehicle body engineering, Prime mover, cooling and lubrication systems. Tyres: types of tyres, tyres specification, factors affecting tyre performance, Special tyres, hydroplaning.

UNIT - II

Transmission and driveline components, friction and fluid clutches, manual and automatic gearbox; propeller shaft, axles, differential

UNIT - III

Brakes and its types, Comparison and details of components, Brake adjustment, ABS. Steering and Suspension; Suspension geometry, types of suspension, shock absorbers, ackermans steering mechanism, steering ratio, steering mechanism, power steering.

UNIT - IV

Introduction to ground vehicle aerodynamics, streamline flow, concept of drag and lift. diffusers, spoilers and wings. Effects of aerodynamics on vehicle performance of race and fleet vehicles.

UNIT - V

Electrical systems–construction. Operation and maintenance of Batteries, Alternator, starter motor, Battery Ignition and magneto ignition systems, Electronic ignition, Lighting, Horn, Side indicator wiper. Automobile air-conditioning, Panel board instruments. Maintenance & troubleshooting. Automotive Lighting, Parking Assistance, Navigational aids, Intelligent Lighting.

UNIT - VI

Recent Trends: Introduction to electric and hybrid electric vehicles, e- mobility, connected and autonomous cars and latest developments.

Text Books

1. Automobile Engineering Vol 1–Kirpal Singh, Standard Publishers.
2. Automotive Mechanics – W. H .Crouse, D. L. Anglin, Tata McGraw Hill Education.
3. Automotive Mechanics – N. K. Giri, Khana Publication.

Reference Books

1. Advance Automotive Technology, Heniz Hitner, SAE International.
2. Motor Vehicle, K. Newton and W. Seeds, T. K. Gawet, Butterworth Heinmann.
3. Automobile Engineering by G. B. S. Narang, Khanna Publisher

VI Semester
Department of Mechanical Engineering

Course Code : MET366-4, Elective-II | **Course : Dynamics of Machinery**

L: 3 Hrs, T: 0 Hr, P: 0 Hrs. Per week | **Total Credits : 03**

Course Objectives

1. To equip the students with fundamental knowledge of dynamics of machines so that student can appreciate problems of dynamic force analysis
2. Develop understanding of flywheel analysis, different speed governors and its force analysis
3. Develop the understanding of vibrations and its significance on engineering design.

Course Outcomes

Students shall be able to

1. Understand the function, analysis of flywheel in an IC engine and punching machines
2. Exhibit skills towards the application of dynamic force analysis
3. Explain, distinguish and analyze different types of speed governors
4. Analyze the free and forced vibrations in SDOF systems
5. Analyze the free and forced vibrations in TDOF systems
6. Determine and analyze natural frequencies and mode shapes of vibrating systems.

Syllabus

Unit - I

Turning moment Vs crank angle diagram for single cylinder and multiple-cylinder engines, concept of Flywheel and its working, coefficient of fluctuation of energy and speed, energy stored in a flywheel, punching machines, riveting machines etc.

Unit - II

Dynamic force analysis of planar linkages such as four bar chain and reciprocating mechanism by graphical method, virtual work method, cam dynamics and jump-off phenomenon

Unit - III

Governors, Speed governors, centrifugal and inertia type, Watt, Portal, Proell, Hartnell governors, operating characteristics of governors, sensitiveness stability, Hunting etc.

Unit - IV

Derivation of equation of motion for vibratory system, Free vibration of single-degree of freedom system with and without damping. Logarithmic decrement and damping estimationForced vibration of single degree of freedom and vibration isolation, whirling of shaft and critical speed of rotors.

Unit - V

Equation of motion for two-degree-of-freedom system, Natural frequencies and mode shapes vibration absorber. Torsional oscillations of two-disc and three-disc rotors with varying cross-sections and gear ratio. Introduction to FFT Analyzer for vibration measurements

Unit - VI

Determination of natural frequencies and mode shapes, Dunkerley's formula, Rayleigh's method, Holzer's method, Matrix Iteration Method etc.

Text Books

1. S. S. Rattan, Theory of Machines, Tata McGraw Hill.
2. R L Norto, Kinematics & Dynamics of Machinery, Tata McGraw Hill.
3. Uicker and Shigley, Theory of Machines and Mechanisms, Tata McGraw Hill.
4. Grover G. K. Mechanical vibrations: Nem Chand & Brothers.

Reference Books

1. J.S. Rao & R.V. Dukki Pati, Mechanism and Machine Theory, New Age International.
2. Thoman Bevan, Theory of Machines, CBS publications.
3. Wilson & Sadler, Kinematics & Dynamics of Machinery, Harper Collins Publishers, 1983,
4. W. T. Thomson, Theory of Vibrations, CBS Publishers & Distributors.

VI Semester
Department of Mechanical Engineering

Course Code : MET366-5, Elective-II **Course : Numerical methods for Mechanical Engineering**

L: 3 Hrs, T: 0 Hr, P: 0 Hrs. Per week **Total Credits : 03**

Course Objectives

The objective of the course is to prepare the students:

1. To learn various numerical methods applied in solving physical problems 2.To develop implementing MATLAB in solving numerical equations

Course Outcomes

At the end of this course students will demonstrate the ability to

1. Understand the MATLAB commands.
2. Identify various kinds of computing errors.
3. Control the computing errors.
4. Know the implementing MATLAB in linear algebraic operations.
5. Process the functions and data.
6. Formulate and solve Finite Difference equations.

1. MAT LAB Usage and Computational Errors

Basic Operations of MAT LAB, Input/output of Data from MAT LAB Command, Window, Through Files and Keyboard, 2-D & 3-D Graphic Output, Mathematical Functions, Operations on Vectors and Matrices, Random Number Generators, Flow Control

2. Computer Errors Versus Human Mistakes, Various Kinds of Computing Errors, Error Propagation, Avoiding Large Errors, Nested Computing, Vector Operation Versus Loop Iteration, Iterative Routine Versus Nested Routine, Runtime Error, Parameter Sharing, Adaptive Input Argument List

3. MAT LAB and Solving Equations

Vectors, Functions, and Plots in MAT LAB, MAT LAB Programs, Newton's Method and Loops, Controlling Error and Conditional Statements, The Bisection Method and Locating Roots, Secant Methods, Symbolic Computations

4. Linear Algebra

Matrices and Matrix Operations in Mat lab, Introduction to Linear Systems, Some Facts About Linear Systems, Accuracy, Condition Numbers and Pivoting, LU Decomposition,Nonlinear Systems - Newton's Method, Eigenvalues and Eigenvectors, Vibrational Modes and Frequencies, Numerical Methods for Eigenvalues

5. Functions and Data

Polynomial and Spline Interpolation, Least Squares Fitting: Noisy Data, Integration: Left, Right and Trapezoid Rules, Integration: Midpoint and Simpson's Rules, Plotting Functions of Two Variables, Double Integrals for Rectangles, Double Integrals for Non-rectangles, Gaussian Quadrature, Numerical Differentiation, The Main Sources of Error

6. Differential Equations

Reduction of Higher Order Equations to Systems, Euler Methods, Higher Order Methods, Multi-step Methods, ODE Boundary Value Problems and Finite Differences, Finite Difference Method - Nonlinear ODE,

Text Books

1. Todd Young and Martin J. Mohlenkamp, Introduction to Numerical Methods and Matlab Programming for Engineers, Edition 2018, Creative Commons Attribution.

Reference Books

1. Won Young Yang, Wenwu Cao, Tae-Sang Chung, John Morris, APPLIED NUMERICAL METHODS USING MATLAB,, A JOHN WILEY & SONS, INC., PUBLICATION

VI Semester
Department of Mechanical Engineering

Course Code : MET399-1,Open Elective-III **Course Name : World Class Manufacturing**

L: 3 Hrs. T: 0 Hrs. P: 0 Hrs. Per week **Total Credits: 03**

Course Objectives

The objective of the course is to prepare students:

1. To understand the Philosophy and Concept of World Class Manufacturing and its role in the continuous improvement of product, process and service, to remain at leading position in the drive of world class performance.
2. To get acquainted with WCM - Principles, Methodology and Technology to actually engage all employees in the process of continuous improvement.

Course Outcomes

On completion of the course the students will be able to:

1. Understand the challenges in manufacturing for global competition.
2. Realize the necessity and importance of world class production.
3. Aware of the technological innovation in manufacturing.
4. Identify the strategies and implementation tools required in competing with the global market.
5. Understand the strategies for world class manufacturing and automated systems.
6. Realize the importance of human factors in production optimization and delivering products in highest possible value.

SYLLABUS

Unit I : Manufacturing competitiveness, quality and global competition, challenges to Indian manufacturers in the global market.

Unit II : Economic liberalization and its impact on manufacturing, necessity of world class production and an overview of world class manufacturing.

Unit III : Advanced manufacturing technologies, CIM, FMS, Cellular manufacturing and Manufacturers Resources Planning (MRP II).

Unit IV : Elements of Lean manufacturing, Quality Strategies for Manufacturing success, JIT, JIT manufacturing systems, TQM, Six Sigma Quality, WCM Model , Technological innovation, Innovative designs.

Unit - V : Automated factories and automated systems, Intelligent manufacturing systems, Factory of the future automated systems, Modeling, optimizing and simulation of manufacturing systems. Tomorrow's factories.

Unit VI : Human factors in automated systems, optimized production technology, Introduction to SCRUM culture.

Text Books

1. K. Shridhara Bhat, World Class Manufacturing, Himalaya Publication House, Mumbai. (2007 edition)
2. B. S. Sahay, K B C Saxena, Ashish kumar, World Class Manufacturing Strategic Perspective, Mac Milan Publication.

Reference Books

1. Operation Management for Competitive Advantage, Chase
2. Production and Operation Management, Pannerselvam, Prentice Hall of India.
3. Industrial Engineering and Production Management, Martand T. Telsang, S.Chand & Co.
4. The Toyota Way, Jeffrey K. Liker, Tata McGrow Hill.
5. The SCRUM Culture (Introducing Agile Methods in Organization), Springer.

VI Semester
Department of Mechanical Engineering

Course Code : MET 399-2, Open Elective-III **Course : Safety and Hazard Analysis**

L: 3 Hrs. T: 0 Hrs. P: 0 Hrs. Per week **Total Credits : 03**

Course Objectives

The objective of the course is to prepare the students:

To recognize and evaluate occupational safety and health hazards in the workplace, and to determine appropriate hazard controls following the hierarchy of controls.

Course Outcomes

The expected learning outcome is that the students will be able to :

1) Understand the safety terms and identify the various hazards around the work environment.
2) Aware of the safety measures while performing work on fire prone equipment and processes.
3) Use the safety measures while performing work on Mechanical Machine Tools and handling materials.
4) Understand the safety measures while performing work with electrical devices and equipment.
5) Realize the importance of safety training, safety displays and its application.
6) Understand importance of safety audit in organization

Unit I:

Introduction to safety, safety terms : definitions, accident, safety, hazard, safe, safety devices, safety guard, security, precaution, caution, appliance, slip, trip, fall. Ladders and scaffolding. Unsafe acts, reason for accidents, OSHA & WHO norms. Safe material handling and storage.

Unit II:

Introduction to fire safety, Fire classes, Fire triangle, Fire extinguishers, Fire hazard and analysis, prevention of fire. Fire protection and loss prevention, steps after occurrence of fire. Portable fire extinguishers. Fire detection, fire alarm and fire fighting systems. Safety sign boards.

Unit III:

Mechanical safety, Personal protective equipments, safety guards, SOP and safety rules to follow while working on Mechanical Machine Tools, Fabrication and forming equipments. Safety while handling materials and material handling devices. Introduction to chemical hazard and safety practices.

Unit IV:

Introduction to electrical safety, effect of electric current on human body, Electric hazards, causes and prevention of electrical accidents, Electric shock and safety precautions

Unit V:

Importance of Safety Education and Training, Identification of training needs, Training methods, Role of government agencies. Needs of creating awareness, safety displays, safety pledge, safety incentive scheme and safety campaign.

Unit VI:

Components of Safety Audit, types of audit, audit methodology, check list – identification of unsafe acts of workers and unsafe conditions on the shop floor. Case studies related to safety practices in industrial/commercial establishments.

Text Books

1. Deshmukh L M, Industrial Safety and Management, McGraw Hill Education (India) private Limited, ISBN-13
2. Rao, Jain R. K. and Saluja, Electrical Safety, fire safety and safety management, Khanna Publishers, ISBN: 978-81-7409-306-6

Reference Books

1. Raju K S N, Chemical process Industrial safety, McGraw Hill Education (India) private Limited, ISBN-13
2. Gerard Kiely, Environmental engineering, McGraw Hill Education (India) private Limited.
3. Publications from International Standard Organizations like ISO, OSHA, IOSH, NEBOSH etc.

VI Semester
Department of Mechanical Engineering

Course Code : MET 399-3,Open Elective-III **Course Name : Energy Auditing**

L: 3 Hrs., T: 0 Hrs., P: 0 Hrs., Per week **Total Credits : 03**

Course Objectives

The objective of the course is to prepare the students:

1. To familiarize with the importance of energy and associated financial management.
2. To develop energy auditing skills in various engineering systems for optimum energy utilization.

Course outcomes

Student will be able to:

1. Understand the process of conduction of energy audit.
2. Apply the financial aspects involved in energy audit.
3. Analyze energy saving techniques in thermal utilities.
4. Implement proper energy saving techniques in thermal systems.
5. Identify energy conservation opportunities in electrical and illumination system.
6. Understand energy conservation opportunities in infrastructure.

Unit :

Energy Scenario: Basics of Energy and its various forms, Energy management and audit, Material and Energy balance, Facility as an energy system, methods for preparing process flow, Global environmental concerns.

Unit II :

Financial Management: Investment need, appraisal and criteria, financial analysis techniques-simple payback period, return on investment, net present value, internal rate of return, cash flows, energy performance contracts and role of Energy Service Companies (ESCOs).

Energy Monitoring and Targeting: CUSUM.

Unit III :

Energy Audit in thermal utilities I: Steam Power Plants, Furnaces, Compressed Air System and HVAC & Refrigeration system

UNIT IV :

Energy Audit in thermal utilities II: Cogeneration, Classification of cogeneration systems, benefits of waste heat recovery, commercial waste heat recovery devices, Fans and blowers, Pumps and Pumping System

Unit V :

Energy Audit in Electrical utilities: Electricity billing, electrical load management and maximum demand control, power factor improvement and its benefit, Electric motors, Lighting System

Unit VI :

Energy Audit applied to Infrastructure Applications: Energy saving measures in New Buildings, Green Building, water audit and water audit methodology, Energy efficiency measures in road transport and infrastructure.

Text Books

1. Archie, W Culp., Principles of Energy Conversion, McGraw Hill, 1991.
2. P. O'Callaghan, Energy Management, McGraw Hill Book Company, 1993.Reference books:
1. Smith C.B., Energy Management Principles, Pergamon Press.
2. Trivedi. P. R; Jolka K.R., Energy Management, Common wealth Publication.
3. Majumder Milli, Energy Efficient Buildings: TERI
4. Bureau of Energy Efficiency Study material for Energy Managers and Auditors Examination: Paper I to IV.

VI Semester
Department of Mechanical Engineering

Course Code : MEP368 | **Course : Comprehensive Viva Voce**

L: 0 Hrs., T: 0 Hrs., P: 2 Hrs., Per week | **Total Credits : 1**

Course Objectives

The Objective of this course is to prepare the students

1) To consolidate, integrate and reinforce the learning and understanding of the previous four semesters so as to get a holistic view of Mechanical Engineering discipline
2) To recapitulate and revise the knowledge gained to become better prepared for facing the campus interviews in the next semester

Course Outcomes

At the end of this course students will demonstrate the ability to

1. Relate the various subjects studied in the previous four semesters
2. Understand the flow of learning and direction of their learning of Mechanical Engineering
3. Progressively build the concepts and fundamentals of the Mechanical Engineering
4. Organize the knowledge of various subjects and get a holistic view of the discipline
5. Take up the Projects/ Internships involving knowledge from various subjects
6. Deal with the real world problems requiring a comprehensive understanding of the Mechanical Engineering

The Comprehensive Viva is aimed at encouraging and enabling the students to develop a holistic view of the Mechanical Engineering discipline. It would help the students to not only revisit all the subjects learnt so far by them but also to broaden and deepen the understanding of various subjects in light of the understanding of the other subjects learnt subsequently. It is expected that the students would not only revise and reinforce the previous learning but also combine, collate and integrate it into one body of knowledge. Such a comprehensive understanding of Mechanical Engineering will be very much useful to them during their projects, internships, research endeavors and finally while performing their jobs.

The students would be evaluated not just on the basis of their knowledge of the individual subjects but also the ability to see the Mechanical Engineering discipline in totality and its relevance, utility and application in engineering industry.

VII Semester
Department of Mechanical Engineering

Course Code : MET451-1 **Course : Stress Analysis (Elective - III)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week **Total Credits : 1**

Course Objectives

- Recognize the various techniques available to measure the stress and strains using different sources.
- Distinguish the principles of photo elasticity in two dimensional stress analyses
- Realize the working of strain measuring instruments.

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Apply the fundamentals of theory of elasticity
2. Use and solve 2-D problems in polar coordinate system
3. Apply the principles and techniques of 2-D photo-elastic measurement
4. Apply the principles and techniques of 3-D photo-elastic measurement
5. Apply the principles and techniques of strain gauge measurement
6. Apply the principles and techniques of brittle coating and moiré analysis

Syllabus

UNIT - I : Two Dimensional Problems in Cartesian Coordinate system

Fundamentals of stress & strain, stress-strain relationship, Elastic constants, plane stress, plane strain, differential equation of equilibrium Boundary conditions, Saint Venant's principle, compatibility equation, Airy s stress function. Stress analysis of cantilever subjected to concentrated load at its end and simply supported beam subjected to uniformly distributed load.

UNIT - II : Two dimensional Problems in Polar coordinate system

General equations of equilibrium in polar coordinate, compatibility equations, stress distribution about symmetric axis, stress analysis of cylinder subjected to internal &external pressure, Pure bending of curved beams, effect of hole on the stress distribution in plates,

UNIT - III : Two Dimensional Photo-elasticity

Introduction to basic optics related to photo-elasticity, stress optic law, plane & circular polariscope arrangements, effect of stressed model in plane & circular Polariscope, Isoclinic &Isochromatics, stress trajectories, calibration of photoelastic material (determination of fringe constant). Various photoelastic materials and their properties, Casting of photoelastic models, Tardy's compensation technique, Separation techniques like, shear difference, oblique incidence

UNIT - IV : Three Dimensional Photo-elasticity

Phenomenon of Stress freezing, Method of stress freezing, slicing techniques, determination of material fringe constant at critical temperature Scaling Model- Prototype relations.

Bi-refringerent coating method, Reflection Polariscope, Introduction to fringe sharpening & fringe multiplication

UNIT - V : Strain Gage Technique For Stress & Strain Analysis

Introduction to electrical resistance strain gages, gauge factor, bridge circuit, bridge balance, output voltage of Wheatstone bridge, balancing of bridge, temperature compensation, various bridge configurations, bonding of strain gages to the specimen, determination of principal strains & stresses using strain rosettes. Environmental effects on performance of strain gages, Strain gage response to dynamic strains, high temperature strain gages & self-temperature compensated gages.

UNIT - VI : Grid Technique of Strain Analysis

Brittle coating method for stress & strain analysis, Moire fringe method for stress & strain analysis

Text Books

1) Timoshenko S.P. & Goodier J.N., Theory of Elasticity, Tata McGraw Hill.

2) Srinath L. S., Experimental Stress Analysis, Tata McGraw Hill.

3) Dr. Sadhu Singh, Experimental Stress Analysis, Khanna Publishers.

Reference Books

1) Dally J.W. & Riley W.F., Experimental Stress Analysis, McGraw Hill.

2) Ray T.K., Experimental Stress Analysis, S. Chand and Company.

3) Richard G Budynas, Advanced Strength and Applied Stress Analysis, Tata McGraw Hill.

4) Holister G.S., Experimental Stress Analysis, Cambridge Univ. Press.

VII Semester
Department of Mechanical Engineering

Course Code : MEP451-1 | **Course : Stress Analysis Lab (Elective - III)**

L: 0Hrs., T: 0Hrs., P: 1Hrs., Per week | **Total Credits : 0.5**

Course Objectives

1. Recognize the various techniques available to measure the stress and strains using
2. different sources.
3. Distinguish the principles of photo elasticity in two dimensional stress analyses
4. Realize the working of strain measuring instruments.

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Understand the characteristics of photo-elastic material
2. Determine the fringe constant of a material
3. Understand and separate the principal stresses
4. Measure stress and strain at a point of interest in a material.

The laboratory will have minimum Eight Practical's based on the syllabus of MET451-1

List of Practical's:

1) Casting of Photo elastic Sheet
2) Preparation of Circular Disk or any model from photo elastic sheet
3) Determination of fringe constant using circular disk.
4) Determination of stresses using at least three photo elastic models
5) Separation of Principal Stresses using any method of stress separation
6) Stress freezing of photo elastic model
7) Fixing of strain gages to the specimen
8) Stress & strain measurement in cantilever beam using strain gages.
9) Study & demonstration of Reflection Polariscope
10) Study & demonstration of Fringe sharpener and multiplier

VII Semester
Department of Mechanical Engineering

Course Code : MET451-2 **Course : Advanced Finite Element Method (Elective-III)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week **Total Credits : 03**

Course Objectives

1. To learn approximate methods to determine solution to ODEs
2. To develop computational methods to solve engineering problems

Course Outcomes

1. Understand the formulation of stiffness matrices
2. Develop solutions to 1-D field problems
3. Estimate solutions to 2-D field problems
4. Know the processing for solvers
5. Analyze eigenvalue problems
6. Understand Element Technology

Syllabus

1. General FEM procedure, Approximate solutions of differential equations: FDM method, W-R technique, collocation least square sub-domain and Galerkin method, Rayleigh-Ritz method Structure of FEA program, Pre and Post processor, commercially available standard packages, and desirable features of FEA packages, Formulation of elemental matrix equation, and assembly concepts.
2. Coordinate system: Global, local, natural coordinate system, Shape functions: Polynomial shape functions, Derivation of shape functions, Natural co-ordinate and coordinate transformation, Linear quadratic and cubic elements, Shape functions using Lagrange polynomials. Convergence and compatibility, Field problem: structural analysis (step-bar, taper-bar), Structural analysis with temperature effect, Thermal analysis, heat transfer from composite bar, fins. Fluid network, analysis of electrical network problems by FEA
3. Trusses, Beams, Two dimensional finite elements formulations, Three-noded triangular element, Four-noded rectangular element, Four-noded quadrilateral element, derivation of shape functions: natural coordinates, triangular elements, and quadrilateral elements, Six-noded triangular elements, Strain displacement matrix for CST element
4. Penalty Method, Lagrange methods, Multipoint Constraints, Concept of Master/Slave entities, Examples of Contact problems, Iso-parametric concepts, basic theorem, Iso-parametric, super-parametric, sub-parametric elements, Concept of Jacobian

5. Finite element formulation of Dynamics, application to free-vibration problems, Lump and consistent mass matrices, Eigenvalue problems, Transient dynamic problems in heat transfer and solid mechanics, Introduction to time-integration methods: Implicit and Explicit methods, Convergence, Impact of Mesh quality on convergence
6. Three dimensional elements: Tetrahedron, Rectangular prism (brick), Arbitrary hexahedron, Three-Dimensional polynomial shape functions, Natural co-ordinates in 3D, Three-dimensional Truss (space trusses), Introduction to material models: Introduction to plasticity (Von-Mises Plasticity), Hyper –elasticity. Generating and using experimental data to model material behavior, Errors in FEA, sources of errors, method of elimination, Patch test.

Text Books

1. Reddy J. N., "Finite Element Method", McGraw-Hill
2. S. S. Rao, "The Finite Element Method in Engineering" , 4th Edition, Academic Press, Elsevier

Reference Books

1. P. Seshu, "Textbook of FE Analysis", Prentice Hall

VII Semester
Department of Mechanical Engineering

Course Code : MEP451-2 **Course : Advanced Finite Element Method Lab (Elective-III)**

L: 0Hrs., T: 0Hrs., P: 1Hrs., Per week **Total Credits : 0.5**

Course Objectives

The objective of the course is to prepare the students:

1. To model and analyze a real-life system/componentfor its static/dynamic and strength/thermal analysis, MEMS and electromagnetics etc
2. To interpret the results from the analysis output and various material models available in most commercial software
3. To carry out the sensitivity analysis through various metrics to quantify the quality of mesh and appropriateness of the FE model of a given system and possible ways and means to validate the model.

Course Outcomes

The students will be able:

1. To model and analyze the common mechanical systems/elements such as uniaxial bar, truss or other structural elements such as beam for displacements and stresses to a variety of mechanical or thermal loading conditions.
2. To verify the output with the analytical solutions, wherever possible, and compare the solutions with manual calculations/their own code.
3. To appreciate the role of the type of elements, element size/number of elements, quality of mesh, etc.
4. To quantify the quality of mesh and appropriateness of the FE model of a given system and possible ways and means to validate the model

Laboratory Practical

The proposed list of experiments to be analysed using commercial Finite Element Software is as given below:

1. Any problem using bar/truss/CST/Axisymmetric element
2. Static structural analysis of a mechanical component/system
3. Estimation of natural frequencies and mode shapes of a mechanical component/system
4. Investigation of Temperature distribution and Heat transfer through a given material
5. Finite Element Analysis of MEMS/Piezo actuators
6. Drop Test of an object
7. Contact Analysis of mechanical components
8. Coupled field analysis for structural & thermal or structural & fluid systems
9. Electrical flux distribution through air gap of armature coil
10. Steady state laminar/turbulent fluid flow through pipe

VII Semester
Department of Mechanical Engineering

Course Code : MET451-3 | **Course : Industrial Robotics (Elective-III)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week | **Total Credits : 03**

Course Objective

Understand the concept of kinematics and dynamics of robots, various actuation & sensing systems and control strategy to develop the complete robotic system.

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Recognize the fundamentals, evolution and advancement of Robotics.
2. Develop the ability to perform kinematic analysis of manipulators.
3. Develop the dynamics and trajectory planning for manipulators.
4. Describe the Sensing, Actuation and control issues of robots.
5. Evaluate the Motion planning and control of mobile robot
6. Evaluate the common industrial and non-industrial applications of Robots

Syllabus

Unit - I : Introduction to Robots

Robot – Definition, Robot Anatomy, Coordinate Systems, Work Envelope, types and classification Specifications – Pitch, Yaw, Roll, Joint Notations, Speed of Motion, Pay Load –Robot Parts and Functions, Need for Robots, Different Applications, Principles and problems in robot design and control.

Unit - II : Kinematics of serial robots

Coordinate frame, mapping and transformation, Forward & inverse kinematics, Representation of joints, link representation using D-H parameters, Examples of D-H parameters and link transforms

Unit - III : Dynamics and trajectory planning of serial robot

Linear and angular velocity of links, Manipulator Jacobians, singularity, dexterity for serial manipulators, Euler-Lagrangian formulation for equations of motion for serial manipulators, Joint and Cartesian space trajectory planning and generation.

Unit - IV : Sensing, Actuation and control

Kinds of actuators – stepper, DC servo and brushless motors, model of a DC servo motor, Types of transmissions, Purpose of sensors, internal and external sensors, common sensors – encoders, tachometers, strain gauge based force-torque sensors, proximity and distance measuring sensors, vision. Classical control concepts using the example of control of a single link, Independent joint PID control, Control of a multi-link manipulator.

Unit - V : Mobile Robotics

Mobile robotics, sensing, control, navigation, path planning algorithms (holonomic, non-holonomic) RGV, AGV; Implementation of Robots in Industries – Various Steps; Safety Considerations for Robot Operations; Economic Analysis of Robots – Pay back Method, EUAC Method, Rate of ReturnMethod.

Unit - VI : Robot Applications Text Books:

1. R. K. Mittal,I. J. Nagrath, "Robotics and Control", McGraw Hill Education, 2017.

Reference Books

1. Mikell P Groover, Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta, "Industrial Robotics, Technology programming and Applications", McGraw Hill, 2012.
2. Craig. J. J., "Introduction to Robotics- mechanics and control", Addison- Wesley, 1999. Introduction to robots and their evolution, Anatomy and classification of robots, what is and what is not a robot, progressive advancements in robots.

VII Semester
Department of Mechanical Engineering

Course Code : MEP451-3 **Course : Industrial Robotics Lab (Elective-III)**

L: 0Hrs., T: 0Hrs., P: 2Hrs., Per week **Total Credits : 02**

Course Outcome

The expected outcome is that the students will

1. Understand and apply techniques of Forward & inverse Kinematic modeling.
2. Apply techniques to real life industrial situations for competent solutions.
3. Initiate a thought process for introduction of robots in manufacturing critical components.
4. List & describe various options for AGvs in different situations.

List of experiments

1. Determination of Transformation Matrix for a 2 DOF manipulator by DH notation.
2. Forward Kinematics of n- DOF manipulator. (Divide the batch in groups).
3. Inverse Kinematics of n- DOF manipulator. (Divide the batch in groups).
4. Determination of Jacobian Matrix for n- DOF manipulator.
5. Dynamic analysis of n- DOF manipulator by Newton-Euler's approach.
6. Dynamic analysis of n- DOF manipulator by Lagrangian-Euler's approach.
7. Trajectory planning of n- DOF manipulator.
8. Robot simulation using MATLAB software.
9. Design of PI controller.
10. Design of AGV for obstacle avoidance.

VII Semester
Department of Mechanical Engineering

Course Code : MET451-4 **Course : Refrigeration and Air Conditioning (Elective-III)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week **Total Credits : 03**

Course Objectives

The objective of the course is to prepare the students:

1. To accustom the fundamental principles and different methods of refrigeration and air conditioning.
2. To evaluate the performance of refrigeration and cryogenics system
3. To carry out cooling load calculation for system design.
4. To accomplish air-duct design.

Course Outcomes

Student will be able to:

1. Understand the old and eco-friendly refrigerants for their selection in refrigeration and air conditioning systems.
2. Understand and apply the principles of thermodynamics to refrigeration and cryogenics systems.
3. Explain the components of refrigeration and air conditioning systems
4. Recognize the psychrometry and design the air conditioning system using heat load calculations.
5. Design of air distribution system for air conditioning system.

Unit - I

Refrigeration: Introduction, history & applications, reversed Carnot cycle.

Refrigerants: Classifications, refrigerant properties, nomenclature of refrigerants, alternate refrigerants, global warming potential & ozone depletion potential, Montreal & Kyoto protocol.

Vapour compression refrigeration system: cycle and its analysis, effect of sub cooling, superheating, polytropic compression & pressure drops on the performance of the system.

Vapour absorption refrigeration system: Introduction, principle, ammonia-Water & lithium bromide-water & three-fluid systems, performance.

Unit - II

Multistage Vapour Compression Refrigeration Systems: Multiple compressor & multiple evaporator systems, cascade refrigeration system. Refrigeration equipments: Compressors, evaporators, condenser and expansion device & control (types & principle only). Defrosting methods, Testing & charging of refrigeration systems.

Unit - III

Other Refrigeration Techniques : Air refrigeration system-Introduction, bell-Coleman cycle, simple, boot-strap and regenerative systems. vortex tube, steam jet and thermoelectric refrigeration systems. Cryogenics: Introduction, application of cryogenics, Joule-Thomson coefficient & inversion curve, air liquefaction methods.

Unit - IV

Psychrometry : Introduction, psychometric properties of air and their relations, psychometric chart, psychometric processes, by-pass factor of coils, air washer, adiabatic saturation temperature, apparatus dew point temperature, Sensible heat factor.

Human Comfort : Thermodynamics of human body, factors affecting human comfort, effective temperature, comfort chart.

Unit - V

Summer, winter, and Year round air conditioning systems. All-air, all-water, & air-water systems, Variable refrigerant volume system, Evaporative air cooling system. Design of various air-conditioning systems, RSHF, GSHF, ESHF. Heat Load Calculations: Data collection for load calculation, various components of heat load estimate, method of cooling load calculation.

Unit - VI

Air Transmission & Distribution : Principle of air distribution, types of grills & diffusers & their selection criteria, air alteration, types of air filters, distribution of air through ducts, Duct types & materials, pressure losses in ducts, equivalent diameter of circular duct for a rectangular duct, duct design methods, duct friction chart, duct arrangement systems. Air conditioning controls.

Text Books

1) Dr. Manohar Prasad, Refrigeration and Air-conditioning, New Age Int. Pub.

2) Rajput R. K., A Textbook of Refrigeration and Air-Conditioning, S.K.Kataria & Sons.

3) Domkundwar & Arora, A Course in Refrigeration & Air conditioning, Dhanpat Rai & Co.

Reference Books

1) Dr. Ballaney P.L., Refrigeration & Air-conditioning, Khanna Publication.

2) Stocker & Jones, Refrigeration & Air-conditioning, McGraw-Hill Publication.

3) Roy J. Dossat, Principle of Refrigeration & Air-conditioning, Pearson Education.

4) Jordon & Priestar, Refrigeration & Air-conditioning, PHI Publication.

VII Semester
Department of Mechanical Engineering

Course Code : MEP451-4 **Course : Refrigeration and Air Conditioning Lab (Elective-III)**

L: 0Hrs., T: 0Hrs., P: 1Hrs., Per week **Total Credits : 0.5**

Course Objectives

The objective of the course is to prepare the students:

1. To carry out the experimental analysis of refrigeration and air conditioning system
2. To take-up the repair and maintenance of refrigeration and air conditioning system.

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Identify, understand the working principle and selection of refrigeration and air conditioning components.
2. Conduct the experiments for performance evaluation of computerized refrigeration and air conditioning test-rigs and comparison with theoretical results.
3. Develop a skill to operate the various tools for the repair and maintenance of air conditioning and refrigeration system.
4. Understand the various instrumentation and controls of refrigeration and air conditioning.

List of Practicals

1. Study of various types of refrigerant compressors.
2. To perform experiments on vapour compression test-rig.
3. Study of miscellaneous refrigeration systems such as vortex tube, thermoelectric, cascade and steam jet.
4. Study of various condensers, evaporators and expansion devices used in refrigeration systems.
5. To perform experiments on air-conditioning test-rig.
6. Study and demonstration of use of various tools and equipments used by a refrigeration mechanic.
7. Study of window air conditioner, packaged air conditioning and automotive air conditioning Systems.
8. Report on visit to air-conditioning or cold storage plant or ice plant or Milk chilling plant.

VII Semester
Department of Mechanical Engineering

Course Code : MET451-5 **Course : Renewable Energy System (Elective-III)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week **Total Credits : 03**

Course Objectives

1. To prepare the students to understand the need of renewable energy utilization.
2. To aware the students about various Renewable Energy Technologies.

Course Outcomes

1. Recognize the need of renewable energy sources.
2. Understand various solar thermal energy conversion systems in detail.
3. Understand the basics of solar photovoltaic systems in detail.
4. Describe the working principle of wind energy conversion systems.
5. Understand the biogas and biomass energy conversion systems.
6. Describe the ocean energy conversion systems.

Syllabus

Unit - I

Global energy scenario, status of solar energy utilization in the world, Introduction to electromagnetic spectrum, solar spectrum, estimation of extraterrestrial radiations, solar constant, air mass, attenuation of solar radiations through atmosphere, solar geometry, measurement of solar radiations, empirical equations for predicting availability of terrestrial radiations

Unit - II

Solar thermal energy conversion: Various concentrating and non-concentrating types of solar collectors, constructional details, performance parameters, solar thermal applications, case studies. Design of solar thermal systems for given requirements

Unit - III

Solar electrical energy conversion: Construction and working of solar cells and PV modules, different PV technologies, Photovoltaic system components and different applications, Design of solar PV systems for the given requirements.

Unit - IV

Wind Energy : Basic principle of wind energy conversion system, site selection consideration, basic components of WECS, classification of WEC systems, applications of wind energy, and various design aspects of WECS.

Unit - V

Biogas : Principle of bio gas generation, constructional details of various biogas plants, factors affecting generation of biogas and methods of maintaining biogas, Bio Mass: Introduction, methods of obtaining energy from biomass, thermal gasification.

Unit - VI

Ocean energy : Ocean thermal electric conversion, open and closed cycle of OTEC, basic principles of tidal power & components of tidal power plants, single & double basin arrangements, Energy from ocean waves, wave energy conversion devices.

Introduction to renewable energy policy framework and various business models.

Text Books

1. G.D. Rai, „Non Conventional Energy Sources , Khanna Publishers, New Delhi.
2. G. N. Tiwari and M. K. Ghoshal, Renewable Energy Sources Basic Principles and Applications, Narosa Publishing House, New Delhi.

Reference Books

1. John Twidell , Tony Weir , „Renewable Energy Resources , Taylor & Francis; 2nd edition, 2005
2. Duffie, J. A. & W. A. Beckman, „Solar Engineering of Thermal Processes , 3rd ed. John Wiley & Sons, Inc., 2006
3. C. S. Solanki, „Solar Photovoltaics: Fundamental Applications and Technologies, Prentice Hall of India, 2009.
4. S.P. Sukhatme, Solar Energy: Principles of Thermal Collection And Storage, Tata Mcgraw-Hill

VII Semester
Department of Mechanical Engineering

Course Code : MEP451-5 **Course : Renewable Energy System Lab (Elective-III)**

L: 0Hrs., T: 0Hrs., P: 1Hrs., Per week **Total Credits : 0.5**

Course Objectives

1. To develop an ability to understand the working of various solar collectors.
2. To develop an ability to carry out the performance analysis of solar thermal and photovoltaic systems.
3. To introduce the utility of various non conventional energy sources.

Course Outcomes

1. Measure and estimate the solar radiations in different situations.
2. Understand the effect of various parameters on the performance of solar thermal and PV systems.
3. Design the solar thermal and PV systems for the given requirement.
4. To understand the significant features of various renewable energy sources.

List of Practicals

1. Measurement of solar radiations using pyranometer in different conditions.
2. To study construction and working of various solar photovoltaic (PV) systems.
3. To study the performance of PV module with varying radiation intensities and module temperature.
4. To study the series and parallel combination of PV modules.
5. To study the effect of tilt angle and shading on the PV output.
6. To study the role of bypass and blocking diodes in photovoltaics.
7. To design the solar photovoltaic system for various applications
8. To study various solar thermal collectors.
9. Performance analysis of liquid flat plate collector in the thermosiphon mode of flow with fixed input parameters.
10. Performance analysis of liquid flat plate collector in the thermo siphon mode of flow with varying tilt angles, radiation intensity and wind speed.
11. Performance analysis of liquid flat plate collector in the forced circulation mode of flow with varying tilt angles, mass flow rates, radiation intensity and wind speed.
12. To design the solar PV systems using various simulation tools.
13. To study various renewable energy systems and their applications.

VII Semester
Department of Mechanical Engineering

Course Code : MET451-6 | **Course : IoT and Industry 4.0 (Elective-III)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week | **Total Credits : 03**

Course Objectives

1. To learn fundamentals of IoT architecture, frame works, communication Technologies and Protocols etc.
2. To develop IoT application for some engineering systems through IDEs like ESP, Arduino and Raspberry

Course Outcomes

1. Understand internet of Things and its conceptual and architectural frame work
2. Recognize communication protocols and technologies
3. Apply web connectivity, data formats and communication gate ways to IoT system
4. Analyze internet connectivity through IP/MAC addresses, HTTP, IoT application layer
5. Evaluate participatory sensing, RFID and WSN technologies
6. Design an IoT system through IDEs for engineering application domain

Syllabus

UNIT - I : The Internet of Things

overview of „Internet of Things , smart hyper connected devices, IoT conceptual framework and architectural views, technology behind IoTs, communication modules and protocols such as MQTT. the sources of IoTs, such as RFIDs and wireless sensor networks, M2M, the concept of wearable watches, smart home and smart cities

UNIT - II : Design Principles for connected devices

The design principles for connected devices, IETF six layered design for IoT applications, ITU-T reference model and ETSI M2M domains and high-level capabilities. first architectural layer/device and gateway domain wireless and wired communication protocols and technologies, second architectural layer/device and gateway domain functionalities which are data enrichment, transcoding, consolidation, privacy issues, and device configuring, management, and ID management

UNIT - III : Design Principles for web connectivity

Design principles for web connectivity, the data format standards, JSON, TLV and MIME for communication, and devices CoAP, CoAP-SMS, CoAP-MQ, MQTT and XMPP protocols for devices connectivity to the web, SOAP, REST, HTTP RESTful and WebSockets methods, which the communication gateway deploys.

UNIT - IV : Internet connectivity principles

Internet connectivity principles. Concepts such as IPv4, IPv6, 6LowPAN, TCP/IP suite of protocols; IP addressing of the IoT devices and MAC address of communication circuits are covered. HTTP, HTTPS, FTP, Telnet and other protocols used at IETF layer 6, application layer by IoT applications/services/processes

UNIT - V : Sensors, Participatory Sensing, RFIDs, and Wireless Sensor Networks

Sensors, examples, working principles and usage technologies, participatory sensing, and Industrial IoT, automobile IoT, IoT Innovations reshaping future automobiles, usages of Internet connectivity of cars, and Vehicle-to- Infrastructure (V2I) technology, usages of actuators, RFID and wireless sensor network technology

UNIT - VI : Introduction to Python Programming and Raspberry PI

General syntax of Python Programming, Libraries (NumPy, SciPy, Pnadas, TensorFlow etc), Raspberry PI, Implementation of IoT with Python, Implementation of IoT with Raspberry PI (Domain based application), case studies in some the domains like Smart city, Smart parking, Smart home, Agriculture, Healthcare, Manufacturing, Pharma

Text Books

1. Raj Kamal, Internet of Things, Architecture and Design principles, 1st Edition, McGraw Hill education (India) Pvt. Ltd.
2. Peter Waher, Learning of Internet of Things, 1st Edition 2015, Packt Publishing.

Reference Books

1. Adrian McEwen and Hakim Cassimally, Designing the Internet of Things, 1st Edition John Wiley and Sons, Ltd.
2. Dr. Guillaume Girardin , Antoine Bonnabel, Dr. Eric Mounier, 'Technologies & Sensors for the Internet of Things Businesses & Market Trends 2014 - 2024',Yole Development Copyrights, 2014.
3. Editors Ovidiu Vermesan Peter Friess,'Internet of Things – From Research and Innovation to Market Deployment', River Publishers, 2014.
4. N. Ida, Sensors, Actuators and Their Interfaces, Scitech Publishers, 2014.

VII Semester
Department of Mechanical Engineering

Course Code : MEP451-6 **Course : IoT and Industry 4.0 Lab (Elective-III)**

L: 0Hrs., T: 0Hrs., P: 1Hrs., Per week **Total Credits : 0.5**

Course Objectives

The objective of the course is to prepare the students:

1. To design IoT architectural layers through IDEs (ESP/Arduino/Raspberry Pi) based on IEEE standards
2. To demonstrate and implement the IoT application for some engineering domain like Home automation, smart cities, Agriculture, Retails, e-mobility etc

Course Outcomes

1. The students will be able to write python code
2. The students will be able to use Arduino connected with sensors.
3. The students will be able to interface with Bluetooth devices/GSM Module
4. The students will be able to display some physical parameters like temperature, pressure humidity etc.

List of Practicals

1. Familiarization with Arduino / Raspberry Pi and perform necessary software installation.
2. To interface LED with Arduino / Raspberry Pi and write a program for Blinking / Fading LED, and/or control LED brightness using Pulse Width Modulation, and/or control LED based on input from serial monitor
3. To interface Buzzer with Arduino / Raspberry Pi and write a program to turn ON/OFF for a specific time
4. To interface DHT11 sensor with Arduino / Raspberry Pi and write a program to print temperature and humidity readings.
5. To interface PIR sensor with Arduino / Raspberry Pi and write a program to turn ON/OFF when push button is pressed or at sensor detection
6. To interface Stepper motor using relay with Arduino / Raspberry Pi and write a program to turn ON/OFF motor for specific steps
7. To interface Servo motor using relay with Arduino / Raspberry Pi and write a program to turn ON/OFF motor for specific duration or Joystick, and/or controlling servo motor from an APP built by MIT App Inventor

8. To interface Ultrasonic Sensor with Arduino / Raspberry Pi and write a program to detect motion.
9. To interface LCD Crystal display with Arduino / Raspberry Pi and write a program to print information/sensor data.
10. To interface Bluetooth with Arduino / Raspberry Pi and write a program to send sensor data to smartphone using Bluetooth.
11. To interface Bluetooth with Arduino / Raspberry Pi and write a program to turn LED ON/OFF when „1 / 0 is received from smartphone using Bluetooth.
12. Write a program on Arduino / Raspberry Pi to upload temperature and humidity data to things peak cloud.
13. Write a program on Arduino / Raspberry Pi to retrieve temperature and humidity data from things peak cloud.
14. Write a program on Arduino / Raspberry Pi to publish temperature data to MQTT broker.
15. Write a program on Arduino / Raspberry Pi to subscribe to MQTT broker for temperature data and print it.
16. 163. Write a program to create TCP server on Arduino / Raspberry Pi and respond with humidity data to TCP client when requested.
17. Write a program to create UDP server on Arduino / Raspberry Pi and respond with humidity data to UDP client when requested.

VII Semester
Department of Mechanical Engineering

Course Code : MET452-1 **Course : Mechanical Vibrations (Elective-IV)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week **Total Credits : 03**

Course Objectives

The objective of the course is to prepare the students:

1. To learn to formulate mathematical/vibratory model for physical/engineering systems
2. To determine natural frequency, mode shapes etc.

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Understand concepts of damped and undamped vibrations in SDF systems
2. Estimate forced vibration response in SDF system
3. Illustrate the applications of numerical techniques to determine response of MDOF system
4. Analyse the vibrations in continuous systems.
5. Apply FEM to rod and beam for modal analyses.
6. Understand vibration standards and vibration condition monitoring.

Syllabus

Unit - I

Types of vibrations, Vibration of single degree of freedom (SDF) system, Undamped free vibrations, Free damped vibrations, Governing Differential Equations, Free damped vibrations, Modelling of stiffness and damping (both Viscous and Coulomb). Estimation of damping by decay plots

Unit - II

Impulse, transient and forced vibration response of SDF, support motion, Theory and practice of vibration isolation. Vibration measuring instruments, vibrometer, accelerometer. Vibration control.

Unit - III

Two-degree freedom system. Application to undamped and damped absorbers. Multi- degree freedom systems. Modal analysis. Rayleigh s and Dunkerley's method. Holzer's method

Unit - IV

Continuous systems governed by wave equation and Euler Bernoulli equation. Free and forced vibrations including modal analysis. Lateral vibration of string, Torsional vibration of uniform shaft, longitudinal vibrations of beams

Unit - V

Finite element based dynamic analysis of simple systems. Variational functional formulation for axial element and Rayleigh - Ritz method. Shape function for rod and beam elements. Derivation of mass and stiffness matrix. Natural frequencies and mode shape computation for simple rod and beam problem.

Unit - VI

Industrial applications - rotors and other systems, vibration standards, vibration-based condition monitoring.

Text Books

1. Singh V.P., Mechanical Vibrations.
2. Rao S S., Mechanical Vibrations, Prentice Hall Publishing Co.
3. Graham Kelly, Mechanical Vibrations, Schaum's series.

Reference Books

1. Kewal Pujara, Vibrations and Noise for Engineers, Dhanpat Rai & co.
2. Meirovitch L., Elements of vibration analysis, McGraw Hill International edition.
3. Thomson W.T., Theory of vibration, CBS Publishers Delhi.
4. Rao J.S. & Gupta K., Introductory Course on Theory and Practice of Mechanical Vibrations:, New Age International.
5. Rao J.S., Advanced theory of vibration, Wiley& Sons Inc.
6. Rao J.S., Vibration condition Monitoring of Machines, Narosa publishing house.

VII Semester
Department of Mechanical Engineering

Course Code : MET452-2 **Course : Power Plant Engineering (Elective-IV)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week **Total Credits : 03**

Course Objective

The purpose of this course is to present the fundamental operations in various power plants to the students.

The objective is also to expose the students to get the insights of economics of power generation and various energy storage devices.

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Investigate the fluctuating loads and probe into economic analysis of power plants.
2. Understand Hydrology; express the working principles, analytical treatment and governing of Hydroturbines.
3. Analyze the steam power cycle & explore the major equipment of a Steam power plant along with coal handling and ash disposals.
4. Explore components, working principles of a gas turbine & diesel electric power plant.
5. Demonstrate various energy storage/recovery systems and abstract of renewable solar, wind energy etc.
6. Explain nuclear energy conversion process; describe various types of nuclear reactors and recognize nuclear waste disposal issues

Syllabus

Unit - I : Economics of Power Generation

Indian Energy scenario, Load curves, various terms & definition, effect of fluctuating load. Power plant economics, Tariffs, load division, and cost of electric energy.

Unit - II : Hydroelectric Power Plants

Hydrology : Rainfall, Runoff, Hydro graph, flow duration curve. Plant capacity estimation. Hydroelectric power plant : Site selection, classification of hydroelectric power plant, different components, prime movers, governing, models & model testing, advantages.

Unit - III : Steam Power Plants

Introduction, Power plant layouts, Analysis of Steam Cycles, Coal : Properties, handling & storage, fuel firing methods, ash & dust handling. Steam generators, steam turbine, condenser and cooling towers.

Unit - IV : Gas Turbine Power Diesel Power Plants

Introduction, classification, various components, different arrangement, governing, methods to improve efficiency. Diesel Electric Power Plant : Introduction, Outline, type of engines, different components, performance, plant layout, comparison with other power plant.

Unit - V : Energy Storage Systems & Renewable Sources of Energy

Peak Load plants, waste heat recovery system. Various energy storage - systems viz. pumped hydro, compressed air, flywheel, battery storage etc. Introduction to unconventional power sources : Solar, wind, Tidal, geothermal etc.

Unit - VI : Nuclear Power Generation

Introduction to Nuclear Engineering : Nuclear reactions & its initiation, fission, component of nuclear reactors. Nuclear Reactors :Types of reactors, PWR, BWR, CANDU etc. Nuclear Waste Disposal : Effects of nuclear waste on environment, its disposal to soil, water, air, sea etc

Text Books

1. Nag P. K. , Power Plant Engineering, Tata Mc- Graw Hill Publications, Third Edition.
2. Domkundwar S., Power Plant Engineering, Dhanpatrai & sons.
3. Rajput R.K., Power Plant Engineering, Laxmi Publications, Fifth Edition.

Reference Books

1. Wakil M.M., Power Plant Engineering, Mc-Graw Hill.
2. Black and Veatch, Power Plant Engineering, CBS Publisher and Distributors.

VII Semester
Department of Mechanical Engineering

Course Code : MET452-3 **Course : Vehicle Dynamics (Elective-IV)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week **Total Credits : 03**

Course Objectives

The objective of the course is to prepare the students:

1. To present a problem oriented in depth knowledge of Vehicle Dynamics.
2. To address the underlying concepts and methods behind Vehicle Dynamics

Course Outcomes

At the end of this course students will demonstrate the ability to:

1. Calculate and refer the loads and forces associated to the vehicles Analyse the behavior of the vehicles under acceleration, ride and braking.
2. Identify the force load interaction between tire and ground and estimate tire slip and its effect on the vehicle.
3. Interpret the vehicles vertical dynamic response ride, pitch, roll.
4. Estimate the vehicles lateral dynamic response during cornering.
5. Illustrate the effect of aerodynamic forces on vehicle handling and performance.
6. Demonstrate the rollover behaviour of rigid and independent suspension vehicle.

Syllabus

Unit - I

Performance Characteristics of Vehicle : SAE Vehicle axis system, Forces & moments affecting vehicle, Earth Fixed coordinate system, Dynamic axle loads, Equations of motion, transmission characteristics, vehicle performance, power limited and traction limited acceleration, braking performance, Brake proportioning, braking efficiency.

Unit - II

Tire Mechanics : Tire Construction, Size and Load Rating, Terminology and Axis System, Tractive Properties, Cornering Properties, Camber Thrust, Aligning Moment, Combined Braking and Cornering, Conicity and Ply Steer, Slip, Skid, Rolling Resistance, Elastic Band Model for longitudinal slip, Simple model for lateral slip, Combined longitudinal/lateral slip (friction ellipse), Taut string model for lateral slip, Magic Tire Formula.

Unit - III

Suspensions : Suspension Kinematics, Suspension types, Solid Axles, Independent Suspensions, Anti-Squat and Anti-Pitch Suspension Geometry, Anti-Dive Suspension Geometry, Roll Center Analysis, Suspension Dynamics, Multi-body vibration, Body and Wheel hop modes, Invariant points.

Unit - IV

The Steering System : The Steering Linkages, Steering System Forces and Moments, Steering System Models, Steering Geometry, Steady Handling (2 DOF steady state model), Understeer and Oversteer, Effect of Tire Camber and Vehicle Roll (3 DOF steady-state model), Transient Handling and Directional Stability (2 DOF unsteady model), Effect of Vehicle Roll on Transient Handling (3 DOF unsteady model), Steady-State and Transient Handling of Articulated Vehicles.

Unit - V

Aerodynamics : Mechanics of Air Flow Around a Vehicle, Pressure Distribution on a Vehicle, Aerodynamic Forces, Drag Components, Aerodynamics Aids.

Unit - VI

Rollover : Quasi-Static Rollover of a Rigid Vehicle, Quasi-Static Rollover of a Suspended Vehicle, Transient Rollover, ride response, recent advancements

Text Books

1. Thomas D.Gillespie, Fundamentals of vehicle dynamics, SAE, 1992
2. WongJ. Y., „Theory of Ground Vehicles , John Wiley and Sons Inc., New York, 2001.

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Department of Mechanical Engineering

Course Code : MET452-4 **Course : Supply Chain Management (Elective-IV)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week **Total Credits : 03**

Course Objectives

The objective of the course is to prepare the students:

1. To understand the concepts of Supply Chain Management.
2. To work in the Supply Chain Management function of organizations

Course Outcomes

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

1. Understand and apply basics of Logistics and SCM in industry
2. Analyse the Inventory control Models
3. Understand application of information for gaining competitive advantage in SCM
4. Make warehousing strategy, its design and operational mechanism of warehouse
5. Understand role of transportation in Logistics& SCM and identify various elements of transportation cost.
6. Learn growing importance of customer service and packaging

Syllabus

UNIT - I

Introduction : Nature and Concept, Value Chain, Functions and Contribution, Framework for Supply Chain Solution, Overview of Logistics: Introduction, Logistical Competitive Advantage, Strategic Logistics Planning Process, Aggregate Planning, Demand Forecasting, Operational Objectives, Components and functions of Logistics Management, Integrated Logistics System, Total Cost Analysis and Trade-off.

UNIT - II

Inventory Control in SCM : Economic Order Quantity Models, Reorder Point Models, Purchase and Production models of inventory control, Quantity discount models etc., MRP, Vendors, Vendor rating system in SCM

UNIT - III

Information : Introduction, Positioning of Information in Logistics and SCM, Logistical Information (LIS), Integrated Information Technology (IT), Solution for Logistics and SCM, Emerging Technologies in Logistics and SCM. Overview of IT tools viz. MS Excel, Tableau, Power BI etc. Case study.

UNIT - IV

Warehousing and Distribution Centres : Introduction, Concepts of Warehousing, Types of Warehousing, Functions of Warehousing, Warehousing Strategy, Warehouse Design, Operational Mechanism of Warehouse.

UNIT - V

Transportation : Introduction, Position of Transportation in Logistics and SCM, Elements of Transportation Cost, Modes, Multimodal Transport, Containerization, Selection of Transportation Mode, Indian Transportation Infrastructure Bottleneck, Transportation Decision (Pricing and Rate), Transportation Network (Routing and Scheduling).

UNIT - VI

Customer Service& Packaging : Introduction, Nature and Concept, Changing Environment and the Importance, Customer Service Costs, Gaps Analysis for Customer Service Measurement, Impediments to an Effective Customer Service Strategy. Protective Packaging: Introduction, Forms of Protective Packaging.

Text Books

1. Agrawal D.K., Logistics and SCM, MacMillan India Ltd.

Reference Book

1. Bhattacharya S.K., Logistics and Supply Chain Management, S CHAND.

VII Semester
Department of Mechanical Engineering

Course Code : MET452-5 **Course : Energy Conservation and Management (Elective-IV)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week **Total Credits : 03**

Course Objectives

The objective of the course is to prepare the students:

1. To accustom the knowledge in the domain of energy conservation.
2. To acquaint the energy management and energy audit.
3. To introduce the information and skills about assessing the energy efficiency of a system.

Course Outcomes

At the end of this course students will demonstrate the ability to:

1. Understand and identify areas of energy conservation in industries.
2. Know the duties and responsibilities of an energy manager and energy auditor.
3. Analyze working of the energy utilizing and generating machines.
4. Practice and utilize the instruments in energy audit process.
5. Understand and implement proper energy saving techniques in boiler, furnaces, compressors and heavy machineries.

Syllabus

Unit - I

Energy Scenario : Basics of Energy and its various forms, Indian Energy Scenario, Energy and Environment

Energy management and audit: Types and methodology, Energy Audit Instruments, case studies Material and Energy balance, Facility as an energy system, methods for preparing process flow, material and energy balance diagrams.

Unit - II

Financial Management : Investment need, appraisal and criteria, financial analysis techniques-simple payback period, return on investment, net present value, internal rate of return, financing options, Energy Monitoring and Targeting: CUSUM.

Unit - III

Energy efficiency and Energy performance in thermal utilities : Boilers, FBC boilers, Furnaces, Steam systems, Heat exchangers, Insulation and refractories, cogeneration, Classification of cogeneration systems, benefits of waste heat recovery, commercial waste heat recovery devices.

Unit - IV

Compressed Air System and HVAC system : Types of air compressors, compressor efficiency, efficient compressor operation, Heating, ventilation, air conditioning and Refrigeration System, Fans and blowers, Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities.

Unit - V

Pumps and Pumping System : Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities. Energy conservation in boiler feed water pump, pumping systems for municipal drinking water, and sewerage, agriculture pump sets. Cooling Tower: Types and performance evaluation, efficient system operation, flow control strategies and energy saving opportunities, assessment of cooling towers.

Unit - VI

Electrical System : Electricity billing, electrical load management and maximum demand control, power factor improvement and its benefit, Electric motors, energy saving opportunities, energy efficient motors, soft starters with energy saver, variable speed drives. Electronic ballasts, Lighting System, Light source, choice of lighting, luminance requirements and energy conservation avenues.

Text Books

1. Archie, W Culp., Principles of Energy Conservation: McGraw Hill, 1991.
2. Callaghan P. O', Energy Management, McGraw - Hill Book Company, 1993.
3. Thuman A and Mehta D Paul, Handbook of Energy Engineering: The Fairmount Press.

Reference Books

1. Smith C.B., Energy Management Principles,, Pergamon Press.
2. Trivedi. P.R., Jolka K.R., Energy Management, Common wealth Publication.
3. Witte, Larry C., Industrial Energy Management and Utilization, Hemisphere Publisher.
4. Amit Kumar Tyagi, Handbook on Energy Audits and Management: TERI.
5. Majumder Milli, Energy Efficient Buildings: TERI.
6. Paul O'Callaghan, Energy Management: McGraw Hill.
7. Bureau of Energy Efficiency Study material for Energy Managers and Auditors Examination: Paper I to IV.

VII Semester
Department of Mechanical Engineering

Course Code : MET452-6 **Course : Micro Machining (Elective-IV)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week **Total Credits : 03**

Course Objectives

The objective of the course is:

1. To accustom students with the knowledge in the domain of micro machining processes.
2. Students will be able to differentiate between micro and macro machining along with its various advancement and applications.

Course Outcomes

After completion of this course the students will be able to:

1. Understand the fundamentals of micro and nano machining methods.
2. Familiarity with the tool based micro-machining processes.
3. Recognize suitable micro manufacturing process for specific application.
4. To understand thermoelectric advanced micro machining processes.
5. Familiarity with the electrochemical nano-chemical micro machining processes.
6. Awareness of various micro metrology inspection techniques.

Syllabus

UNIT - I

Introduction to Micro machining : Macro, micro and nano machining: Principle of micro-machining, Historical background, Classification of micro machining and nano finishing processes, Requirements of micro-machining systems, Nanotechnology.

UNIT - II

Traditional Micro machining Processes : Diamond Turn Machining (DTM) - components and requirements of DTM - material removal mechanism, tool geometry, Micro- milling machining, Micro- grinding.

UNIT - III

Mechanical Advanced Micro machining and Nano-finishing Processes : Introduction of basic elements and mechanism of material removal for processes as Abrasive Jet Micromachining, Ultrasonic Micro machining, Abrasive Water Jet Machining, Abrasive Flow nano finishing.

UNIT - IV

Thermoelectric Advanced Micro machining Processes : Electric Discharge Micro machining, Electric Discharge Grinding, Wire Electric Discharge Micro machining, Laser Beam Micro machining, Electron Beam Micro machining, Ion Beam Machining.

UNIT - V

Electrochemical and Chemical Micro machining Processes : Electrochemical Micro-machining, Electrochemical Micro Grinding, Electro stream Micro drilling, Electrochemical Micro deburring.

UNIT - VI

Micro Metrology : Scanning Electron Microscopy, Optical Microscopy, Atomic Force Microscope, Molecular Measuring Machine, Transmission Electron Microscope, Micro-CMM, Recent trends in micro-machining and applications.

Text Books

1. Jain V. K. , Introduction to Micro-machining, Narosa Publishers, New Delhi (2014)
2. Ghosh, A. and Mullick, S., Manufacturing Science, New Age International (2001).
3. Pandey, P.C. and Shan H.S., Modern Machining Processes, McGraw Hill (2004).

Reference Books

1. Mc Geough J.A., Micro-machining of Engineering Materials, Champan and Hall, Lonodon
2. Jackson M. J., Micro and Nano manufacturing, Springer, 2nd Edition, (2008)
3. Mishra, P.K., Non Conventional Machining, Narosa Publishers, New Delhi (2006).

VII Semester
Department of Mechanical Engineering

Course Code : MET453-1 **Course : Control System (Elective-V)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week **Total Credits : 03**

Course Objectives

The objective of the course is to prepare the students:

1. To introduce the concepts of control systems and develop the ability of formulating mathematical models and designing feedback control systems.
2. An understanding of negative and positive feedback systems and their application to circuit analysis and control system design
3. An understanding of frequency compensation and its application to linear and nonlinear control system design

Course Outcomes

1. Understand fundamentals of control system and control system representation and Develop Mathematical Models for various Physical Systems.
2. Describe quantitatively about transient response, steady state errors and stability of control system.
3. Apply classical method of Root Locus Technique for analysis of control systems. And Frequency analysis of control system using Bode plot, Polar Plot, Nyquist Plot.
4. Understand the fundamentals of Controllers of System.
5. The students will understand different Hydraulic control system components
6. The students will understand working of different pneumatic circuits

Unit - I

Introduction: Concept of open & closed loop control system, Transfer Function:

a) Concept of system: physical system, Physical model, Linear and nonlinear systems, Time variant and invariant system.

b) Mathematical Modeling Equations of physical systems (Mass-Spring-Dashpot system, R-L-C series & parallel circuit) transfer function, Procedure of obtaining transfer function. Electrical system, etc.

Unit - II : Time domain analysis

Typical test signals, Time domain specifications, Steady state response, Types of system, Steady state error constants and steady state error, Numerical examples, transient response, Numerical, Concept of stability, Determination of stability by Routh - Hurwitz criterion.

Unit - III : Frequency domain analysis

Introduction to frequency response, Advantages of frequency domain analysis, Polar plots, Numerical, Bode plots, , Introduction to Nyquist plot,. Definition of Root Locus, Construction of root locus, and Stability from root locus plots

Unit - IV : Controls of Systems

Introduction to Proportional (P), Integral (I) & Derivative (D) controller, individual effect on overall system performance, P-PI & PID control, Force Control and Adaptive Control

Unit - V : Hydraulic Control System

Introduction, Principles of Hydraulic Circuits, Basic Elements of Hydraulic Circuits, Advantages and Disadvantages of Hydraulic Circuits, Control Valves, Hydraulic Pumps, Actuators, Comparison between Hydraulic and Pneumatic Control System, Comparison between Hydraulic, pneumatic and electrical control system, Hydraulic Controllers

Unit - VI : Pneumatic Control System

Introduction, Basic elements of Pneumatic circuits Advantages and Limitations of Pneumatic system, Force balance and Force Distance type controllers Nozzle flapper amplifier Pneumatic Controller

Text Books

1. K. Ogata, "Modern Control Engineering", Pearson India, 3rd Edition
2. Kuo B. C., „Automatic Control System Prentice Hall
3. Nagarath I. J., Gopal M., „Control System Engineering Willey Eastern
4. Gopal .M. – Control System. (Prentice Hall Of India)

Reference Books

1. Norman Nise,"Control System Engineering", Prentice Hall India, Fourth Edition
2. Anand Kumar, "Control System Theory", Prentice Hall India.
3. B. Brogliato, R. Lozano, B. Maschke, O. Egeland, "Dissipative Systems Analysis and Control", Springer Verlag, London, 2nd edition, 2007.

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Department of Mechanical Engineering

Course Code : MET453-2 **Course : Principals of Management (Elective-V)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week **Total Credits : 03**

Course Objectives

The objective of the course is to prepare the students:

1. To understand the working and functions in the business organizations.
2. To become effective managers by applying the concepts of scientific management.

Course Outcomes

1. At the end of this course students will demonstrate the ability to
2. Understand the various management theories and their applications.
3. Understand the nature and functioning of business organizations.
4. Understand the functions of planning and decision making in organizations.
5. Acquire the skills of effectively communicating and motivating.
6. Learn the concepts of directing, coordinating and controlling
7. Know the different types of leaders and theories of leadership

Syllabus

Unit - I

Introduction to Management : Definition, Meaning, Nature, Characteristics, Scope Importance of Management, Management and Administration, Levels of Management, Manager as a Professional, Managerial Functions and Skills, Managerial Effectiveness, Qualities of a Good Manager.

Development of Management Thought, Classical, Neo-Classical and Modern Approaches, Contributions of Management Thinkers.

Unit - II

Organization : Introduction, Meaning, Definition, Functions of Organization, Principles of Organization, Nature or Characteristics of Organization, Importance of Organization Classification of Organizations, organizational Structure, Formal and Informal Organization, Line and staff functions. Departmentalization - Need and Importance, Basis, Centralization and Decentralization, Delegation of Authority, Authority &Responsibility, Span of Control

Unit - III

Planning and Decision Making : Planning - Introduction, Meaning, Definition, Nature , Characteristics, Objectives of Planning, Types of Plans, Steps involved in Planning, Process of Planning, Limitations of Planning, Management by Objectives.

Decision Making -Introduction, Definition, Characteristics of Decision-making, Types of Decisions, Steps involved in Decision Making, Individual vs. Group Decision Making.

Unit - IV

Communicating and Motivating : Communication - Definition, Importance, Process of Communication, Types of Communication, Barriers to Communication, Principles of Effective Communication, Technical Communication.

Motivation -Introduction, Definition, Importance of Motivation, Theories of Motivation, Difference between Motivation and Morale, Job Satisfaction.

Unit - V

Directing Coordinating and Controlling : Directing - Introduction, Definition, Importance, Characteristics, Principles of Direction, Techniques of Direction. Co-ordination - Introduction, Definition, Need, Importance, Characteristics, Principles of Co-ordination, Steps for Effective Co-ordination, Coordination and Co-operation.n Control - Introduction, Definition, Need, Scope, Characteristics of Control, Steps in Control Process, Requirements of Effective Control System, Techniques of Control, Advantages and Limitations of Control.

Unit - VI

Leadership : Introduction, Definition, Need or Importance, Characteristics of Leadership, Qualities of Leadership, Managers as Leaders, Theories of Leadership, Types of Leaders, Leadership Styles, Techniques of Leadership, Team Building and Mentoring.

Text Book

1. Principles of Management P C Tripathi, P N Reddy, Tata Mc Graw Hill, Fifth Edition
2. Principles of Management T Ramasamy, Himalaya Publishing House, First edition

Reference Books

1. Industrial Management, I.K. Chopde, A.M. Shaikh, S. Chand Publisher
2. Principles of Management: Dr. Neeru Vasishth, Taxmann's Publication.
3. Management Principles, Processes and Practices: Anil Bhat & Arya Kumar, Oxford Publications.

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Department of Mechanical Engineering

Course Code : MET453-3 **Course : Electric Vehicle Technology (Elective-V)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week **Total Credits : 03**

Course Objectives

The objective of the course is to

1. To give comprehensive insight into the electric vehicle domain, including EV architecture, e motors, energy storage systems and their control.
2. To expose students to the process of motor sizing, selection of batteries, range and charging time calculations for XEV applications.

Course Outcomes

On completion of this course the students will be able to

1. Enlist the benefits of EVs and differentiate between various EV architectures
2. Analyse the tractive force requirement and chose type of e motor to be used for given application
3. Compare various battery technologies and Identify application specific battery and energy management system
4. Outline modes and types of chargers and emphasize the importance of vehicle to grid communication.
5. Demonstrate the safety requirements as per various AIS standards for EVs and subsystems.
6. Interpret the recent advances and upcoming technologies in the field of electric mobility.

Syllabus

Unit - I : Introduction to Electric Vehicles

History, current perspective of EV, advantages and challenges, EV Efficiency, EV architecture.

Unit - II : EV drives and motors

Tractive effort calculation, Motor Sizing, types of Motor for EV; their working, salient features, advantages etc., e-Motor Control, selection criteria.

Unit - III : EV Energy Storage

Lead Acid battery, Li-Ion Battery, different battery chemistry and their comparison, Types of Cell Construction, pack and battery modules. Terminologies related to batteries, Convertors and Inverters, Battery Management System

Unit - IV : EV Charging & Charging infrastructure

Types of charging, charging modes, charger types, Communication between vehicle and grid, G2V, V2G. Contactless charging, battery swapping, standards for charging infrastructure.

Unit - V : EV Safety, Testing and Certification

Standards for Battery, Motor etc., testing procedure for 2W, 4W, E Rickshaw, Functional Safety, Policy and Business Perspective of EVs.

Unit - VI : Advance Topics & Recent Trends

Fuel Cell types and potential of Fuel Cell Electric Vehicle, Hydrogen as fuel, Connected Mobility and Autonomous vehicles.

Text Books

1. Iqbal Hussain, "Electric & Hybrid Vehicles – Design Fundamentals", Second Edition, CRC Press, 2011.
2. James Larminie, "Electric Vehicle Technology Explained", John Wiley & Sons, 2003.

Reference Books

1. Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals", Third Edition, CRC Press, 2018.

VII Semester
Department of Mechanical Engineering

Course Code : MET453-4 **Course : Composite Materials (Elective-V)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week **Total Credits : 03**

Course Objectives

Upon successful completion of the course, a student

1. Understands the need and the means to develop new materials upon appropriate combination of recognized materials.
2. Is able to predict a wide range of mechanical and physical properties of materials as a function of parameters such as volume fraction, orientation & regularity arrangement and particle aspect ratio.
3. Is capable of comparing/evaluating the relative merits of using alternatives (corresponding to various simple and composite materials) for important engineering and other applications.

Course Outcomes

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

1. Appreciate the industrial need for composite materials.
2. Identify different manufacturing methods and testing procedures available for composite material.
3. Appreciate and Apply the micro mechanics for fiber reinforced composite materials.
4. Recognize and Apply the macro mechanics for fiber reinforced composite materials.
5. Explain the elastic behaviour of composite laminates.
6. Establish the failure criteria for laminates and design laminated structures.

Syllabus

Unit - I : Introduction to composite materials

Introduction, Definition, Classification and characteristics of composite materials Types of fiber and resin materials, functions and their properties, Current and potential advantages of fibre reinforced composites, Applications of composite materials, Military, civil, space, automotive and commercial applications, Comparison with metals, advantages & limitations of composites.

Unit - II : Manufacturing of Fiber and Composites

Manufacture of glass, boron and carbon fibers- Manufacture of FRP components- Open mould and closed mould processes, hand lay up ,RTM, Pultrusion, Filament winding etc.

Testing of Composites: Mechanical testing of composites, tensile testing, Compressive testing, Intra-laminar shear testing, Inter-laminar shear testing, Fracture testing etc.

Unit - III : Elastic Behavior of Composite Lamina using Micromechanics

Introduction, Strength of Materials Approach, Semi- Empirical Models, Elasticity Approach,

Volume and Mass Fractions, Density, and Void Content, Evaluation of the Four Elastic Moduli, Ultimate Strengths of a Unidirectional Lamina

Unit - IV : Elastic Behavior of Composite Lamina Using Macro mechanics

Introduction, Definitions: Stress, Strain, Elastic Moduli, Strain Energy, stress strain relations for general anisotropic materials, specially orthotropic materials, transversely isotropic materials, orthotropic material under plane stress and isotropic materials, relations between mathematical and engineering constants.Unit 5. Elastic Behavior of Multidirectional Laminates: Basic assumptions, laminate code, strain- displacement relations, stress-strain relations of a layer within a laminate, force and moment resultants, Laminate stiffness and laminate compliance, symmetric laminates, balance laminates.

Unit - VI : Failure, Design of Lamina and Laminates

Lamina Strength Failure Theories of an Angle Lamina: Maximum Stress Failure Theory Strength Ratio, Failure Envelopes, Maximum Strain Failure Theory, Tsai–Hill Failure Theory, Tsai–Wu

Laminate : Introduction, Special Cases of Laminates, and Failure Criterion for a Laminate, and Design of a Laminated Composite

Text Books

1. Autar K. Kaw, "Mechanics of Composite Materials", 2nd Ed., CRC Press.

Reference Books

1. Agarwal, B.D. and Broutman, L. J., "Analysis and Performance of Fibre Composites", 3rd Ed., John Wiley & Sons.
2. Srinivasan, K., "Composite Materials: Production, Properties, Testing And Applications", Narosa Publishing House, New Delhi.
3. Jones, R.M., "Mechanics of Composite Materials", 1st Ed., Taylor & Francis.
4. Mukhopadhyay M. Mechanics of composite materials and structures. Universities press; 2005.

VII Semester
Department of Mechanical Engineering

Course Code : MET453-5 **Course : Advanced Heat Transfer (Elective-V)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week **Total Credits : 03**

Course Objectives

The objective of the course is to prepare the students:

1. To familiarize with the fundamental concepts of heat transfer.
2. To design the thermal systems for efficient heat transfer processes.

Course Outcomes

1. At the end of this course students will demonstrate the ability to:
2. Recognize the basic principles of classical heat transfer in real engineering application.
3. Analyse the conduction heat transfer problem.
4. Select and apply appropriate analytical solution techniques and/or correlations to convection heat transfer problems.
5. Analyse the phase-change heat transfer processes.
6. Understand and apply the radiation laws to the radiation heat transfer processes.
7. Compute numerically heat conduction problems in various geometries

Syllabus

Unit - I

Heat conduction with heat generation : Plane wall and cylinder with uniform heat generation, applications. Two-dimensional steady state conduction.

Unit - II

Transient and multi dimensional heat conduction : Exact solution, use of Heisler and Grober chart, integrated method

Unit - III

Heat Transfer through extended surfaces : Steady state analysis and optimization, radial fins of rectangular and hyperbolic profiles- longitudinal fin of rectangular profile radiating to free space.

Unit - IV

Convective Heat Transfer : Forced convection: Introduction, heat transfer in high velocity flow, empirical relations for pipe and tube flow, flow across cylinders, spheres and tube banks, liquid-metal heat transfer

Natural Convection : Introduction, empirical relations for free convection, free convection from vertical planes, cylinders, horizontal cylinders, horizontal plates, inclined surfaces, spheres and enclosed space, non-newtonian fluids, combined free and forced convection

Unit - V

Convection with change of phase : Condensation: Laminar film on a vertical surface, Turbulent film on a vertical surface, Film condensation in other configurations, Drop condensation, effect of non-condensable gases in condensing equipments

Boiling : Pool boiling regimes, Nucleate boiling and peak heat flux, Film boiling and minimum heat flux, Flow boilingUnit-VI

Radiation heat transfer : Radiation effect on temperature measurements, radiation properties of a participating medium, emissivity and absorptivity of gases and gases mixtures, heat transfer from the human body, radiative exchange and overall heat transfer in furnaces.

Text Books

1. Holman J. P. , Heat Transfer, McGraw Hill.
2. Cengel Y. A., Heat Transfer – A Practical Approach, McGraw Hill.
3. D.P. Incropera, P.P. and Dewitt, Fundamentals of Heat and Mass Transfer, Wiley Eastern.

Reference Books

1. Adrian Bejan, Convective Heat Transfer, Wiley India.
2. Kays, Crawford and Weigand, Convective Heat and Mass Transfer, McGraw Hill.
3. Siegel and Howell, Thermal Radiation, McGraw Hill.
4. Kraus A.D., Aziz, A., and Welty, J., Extended Surface Heat Transfer, McGraw Hill
5. Adrian Bejan, Allan D. Krams, Heat Transfer Handbook, John Wiley & Sons.

VII Semester
Department of Mechanical Engineering

Course Code : MET453-6 **Course : Mobile Robotics (Elective-V)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week **Total Credits : 03**

Course Objective

This course will present various aspects of design, fabrication, motion planning, and control of intelligent mobile robotic systems.

Course Outcomes

At the end of this course students will able to

1. Explain about mobile robot and robot locomotion.
2. Illustrate and solve problems related to robot kinematics and dynamics.
3. Describe and apply the concept of mobile robot perception.
4. Use and apply any one of the localization techniques.
5. Apply path planning and navigation algorithms.
6. Appreciate and use advanced techniques for robot navigation and to design intelligent robots.

Unit - I : Introduction to mobile robots

Mobile robot, definition, types of robots, Applications of Mobile Robot.

Robot Hardware Robot locomotion, Types of locomotion, hopping robots, legged robots, wheeled robots, stability, maneuverability, controllability,

Unit - II : Robot kinematics and dynamics

Forward and inverse kinematics, holonomic and nonholonomic constraints, kinematic models of simple car and legged robots, dynamics simulation of mobile robots;

Unit - III : Perception

Sensors Proprioceptive/Exteroceptive and passive/active sensors, performance measures of sensors, sensors for mobile robots like global positioning system (GPS), Doppler effect-based sensors, vision-based sensors, uncertainty in sensing, filtering;

Unit - IV : Localization

Odometric position estimation, belief representation, probabilistic mapping, Markov localization, Bayesian localization, Kalman localization, positioning beacon systems;

Unit - V : Introduction to Path Planning and Navigation

Introduction, Path Planning, offline and online path planning, obstacle avoidance, pathplanning algorithms based on A-star, Dijkstra, Voronoi diagrams, probabilistic roadmaps (PRM), Potential field etc.

Unit - VI : Advanced Topics

AI based techniques for navigation, Bio Inspired Algorithm, Multiple robot coordination. Design of intelligent robots

Text Book

1. R. Siegwart, I. R. Nourbakhsh, "Introduction to Autonomous Mobile Robots", The MIT Press, 2011

Reference Books

1. Selected readings from the research literature, to be distributed in class.

VII Semester
Department of Mechanical Engineering

Course Code : MET454-1 **Course : Design of Mechanical System (Elective-VI)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week **Total Credits : 03**

Course Objectives

1. The objective of the course is to prepare the students:
2. To understand various design considerations for various mechanical systems and further apply the same to design it.

Course Outcomes

At the end of this course students will able to:

1. Understand the need and applications of material handling system.
2. Design various components of EOT crane.
3. Design a cross and horizontal girder.
4. Design various IC Engine Components.
5. Design of main components of gear pump.
6. Design of main components of centrifugal pump.

Unit - I

Introduction and Overview of mechanical system. Design consideration in mechanical systems. Basic objectives of material handling system, Types of load, Classification and application of various Material handling equipment, Basic principles in selection of material handling system

Unit - II

Design of components of EOT crane; Design of Hoisting mechanism: Design of hook, design and selection of rope, design of sheaves and pulley, rope drum, selection of bearing for rope drum, gearbox design

Unit - III

Trolley and wheel design, design of cross and horizontal girder.

Unit - IV

IC Engine Components: Design of cylinder and Cylinder head, Design of piston, Design of connecting rod, Design of crankshaft and Design of valve-gear mechanism.

Unit - V

Design of pump : Design of main components of gear pump: 1. Motor selection2. Gear design3. Shaft design and bearing selection4. Casing and bolt design5. Suction and delivery pipe.

Unit - VI

Design of main components of centrifugal pump:1. Motor selection2. Suction and delivery pipe3.Design of Impeller, Impeller shaft,4. Design of Volute casing.

Text Books

1. PATIL S.P. , „Mechanical System Design JAICO students Ed., JAICO Publishing House, Delhi1
2. Rudenko – „Material Handling Equipment M.I.R. publishers, Moscow.

Reference Books

1. Farazdak Haideri, Mechanical System Design, Nirali Prakashan.

VII Semester
Department of Mechanical Engineering

Course Code : MET454-2 **Course : MEMS (Elective-VI)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week **Total Credits : 03**

Course Objectives

The objective of this course is to provide students with

1. Fundamental understanding of standard micro-fabrication techniques
2. Understanding of working principles of microsensors, actuators used in smart devices
3. Major classes, components, and applications of MEMS devices/systems

Course Outcomes

Upon the completion of this course, students will demonstrate the ability to

1. Apply the principles behind the operation of MEMS devices
2. Choose a micro-machining technique for a specific MEMS fabrication process
3. Understand recent advancements in the field of MEMS and devices.

Syllabus

UNIT - I

Introduction to MEMS : Benefits of Miniaturization, Types of MEMS: Optical MEMS, Bio- MEMS, RF-MEMS, Microfludics, Success Stories, Pressure sensor, Accelerometer, Micro-mirror TV Projector.

UNIT - II

Micro-fabrication and Micro-machining : Integrated Circuit Processes, Bulk Micro-machining, Isotropic Etching and Anisotropic Etching, Wafer Bonding, High Aspect-Ratio Processes (LIGA), MEMS Device fabrication using Bulk Micro-machining.

UNIT - III

Surface Micro-machining : One or two sacrificial layer processes, Surface micro-machining requirements, Device fabrication using Surface Micro-machining example, Microcantilever fabrication.

UNIT - IV

RF MEMS Devices : Capacitor, Inductor, Switches, and antennas, RF MEMS components in communications, space and defence applications.

UNIT - V

Physical Micro Sensors : Classification of physical sensors, Integrated, Intelligent, or Smart sensors, Sensor Principles and Examples: Thermal sensors, Electrical Sensors, Mechanical Sensors, Chemical and Biosensors.

UNIT - VI

Microactuators : Classification of microactuators, Electrostatic, Electromagnetic and Thermal microactuation, Mechanical design of microactuators, Microactuator examples, microvalves, micropumps, micromotors.

Text Books

1. Micro and Smart Systems: Ananthasuresh, G. K., Vinoy, K. J., Gopalakrishnan, S., Bhat, K. N., and Aatre, V. K., Wiley-India, New Delhi, 2010. 1st Edition.
2. RF MEMS and Their Applications: Vijay Varadan, K. J. Vinoy, K. A. Jose, Wiley, 2002, 1st Edition.

Reference Books

1. Microsensors, MEMS and Smart Devices , Julian W. Gardner , Vijay K. Varadan, Osama O. Awadelkarim, Wiley ,2001 by Edition: 1st Edition.
2. VLSI Technology, Sze S.M., Mc Graw Hill, 2ndEdition.

VII Semester
Department of Mechanical Engineering

Course Code : MET454-3 **Course : Engineering Economics and Cost Estimation (Elective-VI)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week **Total Credits : 03**

Course Objective

This course intends to expose the students to the world of finance, intricacies of doing financial calculations with respect to different facets like evaluation of alternatives, financial accounting and costing so as to build a rationale while taking decisions in personal and professional life.

Course Outcomes

Students shall be able to

1. Understand the types of organisation, source of funding and necessity of stock markets
2. Appreciate the basic mechanics of interest calculations
3. Apply the techniques for evaluation of alternatives for better decision making
4. Analyze and interpret the financial statements
5. Distinguish types of costs and costing procedures and apply it for ascertainment of costs of a product or a process.
6. Recognize and use the power of Break even analysis, CVP analysis and budgeting for informed decision making.

Syllabus

UNIT - I

Definition & Scope of Finance Function, financing of Engineering Enterprises, ownership & borrowed capital, equity shares, preferential share, debentures, bonds etc. individual ownership. partnership. joint stock company, concept of start-ups, company formation, introduction to capital market, stock markets - objectives & operations.

UNIT - II

Engineering economy, principles of money -time relationship, the nature & purpose of engineering economy, simple interest, compound interest, discounted cash flow diagram, present, future & annual worth, nominal and effective interest rates, compounding more often than once per year, gradient series

UNIT - III

Applications of engineering economy, methods of making engineering economy studies, basic concepts, study period (equal & unequal), equivalent worth methods, rate of return methods, payback period methods, mutually exclusive investment alternatives in terms of combination of projects, depreciation, methods of depreciation,

UNIT - IV

Elements of accounting, preparation and interpretation of profit and loss accounts and balance sheet, analysis of financial statements, use of ratios, index analysis, common size analysis, trend analysis, Du-Pont chart, exposure to one of the standard financial accounting software package.

UNIT - V

Costing : Cost concepts, classification of cost, material, labour and overhead costs, overhead allocations and absorption, Costing Systems, Job Costing, Batch Costing, process costing with normal & abnormal losses & gains, standard costing & variance analysis.

UNIT - VI

Management accounting, marginal costing, break even analysis - CVP analysis, application of costing to decision making like make or buy, add or drop, operate or shut down etc., budget & budgetary controls, concepts of budgeting, advantages & limitations of fixed & flexible budget.

Text Books

1. Sullivan, W.G., J.A. Bontadelli, and E.M. Wicks (2000), Engineering Economy, Pearson Education Asia, 11th Edition.
2. Horngren C.T., G.L. Sundem, and W.O. Stratton (2002), Introduction to Management Accounting, Pearson Education, 12th Edition.
3. Financial Management (Theory & Practice) -Prasanna Chandra - Tata McGraw-Hill
4. Practice in Accountancy – Shankar Prasad Basu & Monilal Das –Amit Kumar Biswas
5. Cost Accounting - Jawahar Lal & Seema Srivastava - 4ed - Tata McGraw-Hill.

Reference Books

1. Engg. Economics and Costing - Sasmita Mishra, Prentice Hall
2. Engineering Economics - R. Panneerselvam, Prentice Hall
3. Degarmo, E.P., Sullivan, W.G. and Canada, J.R, “Engineering Economy”, Macmillan, 1984.

VII Semester
Department of Mechanical Engineering

Course Code : MET454-4 **Course : Material Handling Systems (Elective-VI)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week **Total Credits : 03**

Course Objectives

The course aims to provide fundamental knowledge of material handling equipments. Design and analysis of hoisting equipments like drum, hook, chain, pulley and design of arresting gear, conveyor and elevators.

Course Outcomes

After completion of this course the students will be able to-

1. Understand importance of material handling in a plant
2. Demonstrate the understanding of mechanism and working of various materials handling systems.
3. Exhibit skill towards selection and design of material handling system according to the type of material to be conveyed.
4. Study various components of material handling system
5. Identify the appropriate material handling systems to suit the said requirement.

Syllabus

Unit - I

Importance of material handling, characteristics and classification of materials, Unit load, Bulk load, Principals of material handling, classification of material handling equipments, economics of material handling.

Unit - II

Unit load handling, Pallets, skids, containers, packaging for materials handling.

Industrial trucks, hand trucks, power trucks, fork lift trucks, tractors, common designs, and standards. Bulk material handling equipments.

Unit - III

Conveyors: Belt conveyors, chain conveyors, screw conveyors, roller conveyors, vibrating and oscillating conveyors; types, construction, power calculations and design practice.

Unit - IV

Cable conveyors, bucket conveyors, haulage conveyors: types, components, construction. Pneumatic and hydraulic conveyors: types, components, construction, capacity.

Unit - V

Hoisting equipments : Components of hoisting equipment, pulley systems, arresting gears and brakes, load handling attachments, hoists, winches, constructional features.

Cranes : Stationary, stationary revolving, mobile, derricks, components, constructional details Elevators: bucket elevators- type, buckets, capacity calculations, freight elevators.

Unit - VI

Auxiliary equipments, hoppers, gates, feeders, positioners, ball tables, pallet loader and unloader, weighing and control equipments

New material handling devices: AGV's, and robots; classification, construction, applications. Maintenance and safety in material handling.

Text Books

1. Introduction to Materials Handling, Siddhartha Ray, New Age International Publishers, India.
2. Aspects of Materials Handling, Dr. K. C. Arora , Vikas and V. Shinde, Laxmi Publications, India.
3. Plant layout and material handling ,G.K. Agarwal, Jain Book Depot
4. Materials handling: principles and practice, Theodore Henry Allegri , CBS Publishers, New Delhi

Reference Books

1. Plant layout and material handling, James MacGregor Apple, Wiley
2. Materials Handling Handbook, David E. Mulcahy, McGraw-Hill
3. Material Handling, Immer, J.R., McGraw-Hill
4. Material handling systems design by James MacGregor Apple, Ronald Press Co.
5. Materials Handling Equipment- N. Rudenko , Peace Publication.

Materials Handling Equipment, M.P. Aleksandrov, Central Books Limited

VII Semester
Department of Mechanical Engineering

Course Code : MET454-5 **Course : Project Management (Elective-VI)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week **Total Credits : 03**

Course Objective

1. The students will learn the tools and techniques for effective management of resources and cost in projects.
2. The students will discover various network techniques used in project management.
3. Students will be introduced to computerized project management systems.

Course Outcomes

Students will be able to:

1. Understand the terminology of Project Management.
2. Portray the project management environment and functions.
3. Describe Performance Measurement in project management.
4. Identify the resources needed for each stage, including involved stakeholders, tools and supplementary materials.
5. Demonstrate the Network Scheduling Techniques and Project Graphics.
6. Provide internal stakeholders with information regarding project costs by considering factors such as estimated cost, variances and profits.

UNIT - I

Overview of Project Management, Classification of Projects, Project Management Growth: Concepts and Definitions, Organizational Structures used in Project Management

UNIT - II

Organizing and Staffing the Project Office, Team Management Functions in a Project Environment, the Project Organizational Chart, Management of time and stress conflicts

UNIT - III

Special Topics in Project Management, Working With Executives, Performance Measurement, Financial Compensation and Rewards, Effective Project Management in the Small Business Organization

UNIT - IV

Project Planning, the Statement of Work, Project Specifications, Milestone Schedules, Work Breakdown Structure, WBS Decomposition Problems, Role of the Executive in Project Selection.

UNIT - V

Network Scheduling Techniques, Project Graphics

UNIT - VI

Introduction, Understanding Control, the Operating Cycle, Budgets, Variance and Earned Value, Status the Bathtub Period, Methodology for Trade-off Analysis, Contracts.

Text Book

1. Harold Kerzner, Project Management A Systems Approach to Planning, Scheduling and Controlling, Eight Edition, Wiley & Sons, Inc.
2. Nagarajan K., Project Management, Second Edition, New Age International Publishers.

Reference Book

1. Harold Kerzner, Project Management with Workbook Case Studies Microsoft Project 2002 Trial Edition and Student Survey Set, 8th Edition, Wiley & Sons, Inc., 2004.

VII Semester
Department of Mechanical Engineering

Course Code : MET454-6 **Course : Artificial Intelligence and Expert Systems (Elective-VI)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week **Total Credits : 03**

Course Objectives

1. To present a problem oriented in depth knowledge of Artificial Intelligence and Robotics.
2. To address the underlying concepts, methods and application of different Artificial Intelligence and Expert System.

Course Outcomes

1. To study, analyze and simulate different AI techniques, different expert systems, etc.
2. To develop the concepts of AI in real life applications.
3. To study and apply the use of artificial intelligence in machine through the natural language programming.
4. To study the architecture of expert systems and understand the knowledge rule based systems in AI.
5. To learn and Implement OOPs in an expert system.

Syllabus

Unit - I

Human and machine intelligence, artificial intelligence (AI), programming in AI environment, natural language processing (NLP), architecture of an expert system

Unit - II

knowledge base, inference engine forward and backward chaining, use of probability and fuzzy logic, selection of inference mechanism, semantic nets, structure and objects, ruled systems for semantic nets, certainty factors, automated learning.

Unit - III

Introduction to rule based system, conflict resolution, advantages and drawbacks of rule based systems clausal form logic; rule base verification, refinement and validation creating knowledge base, knowledge engineer and domain expert, phases of knowledge engineering, tools for knowledge engineering

Unit - IV

Neural network applications, artificial neural network models, NN applications in cellular manufacturing and other areas of mechanical engineering

Unit - V

Fundamentals of OOP (Object Oriented Programming), creating structures and objects, object operations, invoking procedures, programming applications, object oriented expert systems.

Text Books

1. Addis, T.R., „Designing Knowledge Based System , Prentice Hall, 1985.
2. Rolston, D.W., „Principles of Artificial Intelligence and Expert Systems Development , McGraw Hill, 1988.
3. Maus, R. and Keyes, J., „Handbook of Expert Systems in Manufacturing , McGraw Hill, 1991

Reference Books

1. Robert Levine, „A comprehensive guide to artificial intelligence and expert systems ,
2. Elain Rich , „Artificial Intelligence , PHI Publication
3. Sasikumar, Ramani, et al , „Rule based expert systems .
4. Graham Winstanley, „Program Design for Knowledge Based Systems , Galgotia Publications.

VII Semester
Department of Mechanical Engineering

Course Code : MET498-1 **Course : Mechatronics (Open Elective-IV)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week **Total Credits : 03**

Course Objectives

1. Integrate and apply engineering knowledge and skills to problems and challenges in the areas of mechatronic engineering

Course Outcomes

The expected learning outcome is that the students will be able to:

1. understand and recognize the synergistic combination of all related branches of engineering.
2. have adequate multi-disciplinary knowledge and conceptual skills
3. apply knowledge about sensors and actuators for selection for a typical application.
4. Explain construction and working of CNC machines as Mechatronic systems.
5. Understand and apply the design process of a Mechatronics system.
6. Gain the knowledge on advanced applications in Mechatronics

Syllabus

1. Introduction

Introduction to Mechatronics Systems, Definition of Mechatronics, Classification and Description of Mechatronic using Graphical and Block Diagram Method, Multi- disciplinary scenario, origins. Evolution of Mechatronics, Mechatronics key elements, Mechatronics design process, Need for mechatronics in industries, Objectives, advantages and disadvantages of mechatronics.

2. Sensors and Transducers

Introduction to Sensors and Transducers: Performance Terminology Displacement, Position and Proximity-Velocity and Motion-Fluid, Classifications of different sensors used in mechatronics systems.

3. Actuation Systems

Pneumatic and Hydraulic system, mechanical and electrical actuation systems. Smart materials and Systems – Piezoelectric actuators– Shape memory alloy (SMA) actuators, Magneto rheological and Electro rheological Fluids and its applications; Dampers, Clutch, Valves etc.

4. Elements of CNC Machines

Introduction to Computer Numerical Control, Features of CNC Machines, Structure, Drive Mechanism, gearbox, Main drive, feed drive, Spindle Motors, Axes motors. Timing belts and pulleys, Spindle bearing – Arrangement and installation, Slide ways, Re - circulating ball screws – Backlash

measurement and compensation, linear motion guide ways, Retrofitting of Conventional Machine Tools, Description of a simple CNC control system. Types of measuring systems in CNC machines.

5. Design of Mechatronics System

Stages in designing Mechatronics Systems– Traditional and Mechatronic Design-Possible Design Solutions, Intelligent techniques in mechatronics – algorithms man machine interface- case studies

6. Applied Mechatronics

Principle of working of automatic camera, engine management system, and automatic washing machine. Pick and Place robot, Mechatronics design in Automated car parking system, Automated Washing Machine System, Automated Traffic signal Method,. Case studies in: Mechatronics in Home appliances, Medical Devices, Defense, Automobiles and office automation, Industrial Automation, Future of Mechatronics.

Text Books

1. Bolton W., "Mechatronics : Electronic Control Systems in Mechanical and Electrical Engineering"– 4th Edition. Pearson Education; 4 edition (2010).
2. Nitaigour and Premchand Mahilik, Principles, Concepts and applications - Mechatronics, Tata McGraw Hill – 2003.

Reference Books

1. Devdas Shetty and Richard A. Kolk "Mechatronics System design" 2nd Edition Cengage learning, (2012).
2. David G. Alciatore and Michael B. Histand, Introduction to Mechatronics and Measurement systems, 2nd edition Tata McGraw-Hill, 2003.

VII Semester
Department of Mechanical Engineering

Course Code : MET498-2 **Course : Industrial Robotics (Open Elective-IV)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week **Total Credits : 03**

Course Objective

Understand the concept of kinematics and dynamics of robots, various actuation & sensing systems and control strategy to develop the complete robotic system.

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Recognize the fundamentals, evolution and advancement of Robotics.
2. Suggest and select drives and end effector of robot.
3. Develop the dynamics and trajectory planning for manipulators.
4. Describe the Sensing, Actuation and control issues of robots.
5. Develop the ability to perform kinematic analysis of manipulators.
6. Describe the common industrial and non-industrial applications of Robots

Syllabus

Unit - I : Introduction to Robots

Robot Definition, Robot Anatomy – Co-ordinate Systems, Work Envelope, types and classification Specifications, Pitch, Yaw, Roll, Joint Notations, Speed of Motion, PayLoad –Robot Parts and Functions – Need for Robots – Different Applications, Principles and problems in robot design and control.

Unit - II : Robotics Drives and Grippers

Pneumatic Drives – Hydraulic Drives – Mechanical Drives – Electrical Drives – D.C. Servo Motors, Stepper Motor, A.C. Servo Motors – Salient Features, Applications and Comparison of Drives End Effectors – Grippers – Mechanical Grippers, Pneumatic and Hydraulic Grippers, Magnetic Grippers, Vacuum Grippers; Two Fingered and Three Fingered Grippers; Internal Grippers and External Grippers; Selection and Design Considerations.

Unit - III : Robotic Sensors

Sensors-Position sensors, Velocity sensors, Proximity sensors, Touch and Slip Sensors, Force and Torque sensors. Applications – Inspection, Identification, Visual Serving and Navigation.

Unit - IV : Robot Programming and Control

Robot programming: Programming of Robots and Vision System- overview of various programming Languages.

Control architecture- position, path velocity and force control systems, computed torque control, Adaptive control, and Servo system for robot control.

Unit - V : Kinematics of serial robots

Coordinate frame, mapping and transformation, Forward & inverse kinematics, Representation of joints, link representation using D-H parameters, Examples of D-H parameters and link transforms.Introduction to trajectory planning and dynamics of robots.

Unit - VI : Applications

Application of Robots in production systems- Application of robot in welding, machine tools, material handling, and assembly operations parts sorting and parts inspection. Non industrial applications: domestic, medical, military operations, children toys, humanoids. Robot safety.

Text Books

1. R. K. Mittal, I. J. Nagrath, “Robotics and Control”, McGraw Hill Education, 2017.

Reference Books

1. Mikell P Groover, Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta, “Industrial Robotics, Technology programming and Applications", McGraw Hill, 2012.
2. Craig. J. J., “Introduction to Robotics- mechanics and control”, Addison- Wesley, 1999. Introduction to robots and their evolution, Anatomy and classification of robots, what is and what is not a robot, progressive advancements in robots.

VII Semester
Department of Mechanical Engineering

Course Code : MET498-3 **Course : Functional Safety (Open Elective-IV)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week **Total Credits : 03**

Course Objectives

The objective of the course is to prepare the students:

1. To learn functional safety aspects in product or system design and development.
2. To apply functional safety aspects in automotive

Course Outcomes

The expected learning outcome is that the students will be able to:

After studying the course, the student will be able to:

1. Understand ISO 26262
2. Illustrate the Architecture in functional safety
3. Analyze the system engineering components
4. Formulate safety aspects in product development
5. Apply system Integration.
6. Demonstrate functional safety audits.

Syllabus

1. Functional Safety in Road Vehicles : Introduction to Functional safety, Definitions and Translations from the ISO 26262, Error Terms of the ISO 26262 Risk, Safety and Functional Safety in Automobiles, Quality Management System, Quality Management Systems from the View point of ISO 26262 Advanced Quality, Planning Process Models V-Models, Waterfall Model, Spiral Model, Automotive and Safety Lifecycles, Safety Lifecycles for the Development of Automotive Products, Safety-Lifecycles According to ISO 26262, Security-Versus Safety Lifecycles

2. System Engineering : Historic and Philosophic Background, Reliability Engineering, Foundation/Basis of Reliability, Reliability and Safety, Architecture Development, Stakeholder of Architectures, Views of Architecture Horizontal Level of Abstraction, Requirements and Architecture, Development, Requirements and Design Specification.

3. System Engineering for Development of Requirements and Architecture : Function Analysis, Hazard and Risk Analysis, Hazard Analysis and Risk Assessment according to ISO 26262, Safety Goals, Safety Concepts, The Functional Safety Concept, Technical Safety Concept, Microcontroller Safety Concept, System Analyses, Methods for the System Analysis, Safety Analysis According to ISO 26262, Safety and Security Error, Propagation, Verification During, Product Development at System

Level, Product Development at Component Level, Mechanical Development, Electronic Development, Software Development.

4. System Engineering in the Product Development : Product Realization, Product Design for Development, Mechanics, Electronics, Software, Functional Safety and Timing Constraints, Safety Aspects of Fault-Reaction-Time-Interval, Safety Aspects and Real-Time Systems, Timing and Determinism, Scheduling Aspects in Relation to Control-Flow and Data-Flow Monitoring, Safe Processing Environment.

5. System Integration : Verifications and Tests, Basic Principles for Verifications and Tests, Verification based on Safety Analyses, Verification of Diverse Objectives such as Safety and Security, Test Methods, Integration of Technical Elements, Safety Validation, Model Based Development, Models for Functional Safety, Foundation for Models, Model Based Safety Analysis, Approvals/Releases, Process Releases, Release for Series Production, Production Part Approval Process (PPAP)

6. Confirmation of Functional Safety : Confirmation Reviews, Functional Safety Audits, Assessment of Functional Safety, Safety Case

Text Book

1. Ross H. L., Functional safety for road vehicles (New Challenges and Solutions for E-mobility and Automated Driving), 2016 Edition, Springer publication, ISBN 978-3-319-33360-1

Reference Book

1. Bergmiller, Peter, Towards Functional Safety in Drive-by-Wire Vehicles 2015 Edition, Springer publication, ISBN 978-3-319-17484-6.

VII Semester
Department of Mechanical Engineering

Course Code : MET498-4 **Course : Condition Monitoring (Open Elective-IV)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week **Total Credits : 03**

Course Objectives

The objective of the course is to prepare the students:

1. To understand the objectives, aims and methodology of machine tool condition monitoring and diagnostics.
2. To make students aware of a range of techniques from Vibration based methods, spectrography and other condition based method s of machine fault diagnosis.

Course Outcomes

1. At the At the end of this course the student shall be able to:
2. Understand the types of maintenance used and its significance, role of condition based maintenance in industries, familiarize with different condition monitoring techniques and its advantages in industries.
3. Implement the basic signal processing techniques.
4. Understand the role of vibration monitoring, its methodology and its use in condition monitoring of rotating and reciprocating machines.
5. Understand the significance of mechanical fault diagnosis andnon-destructive testing techniques in monitoring and maintenance.
6. Study condition monitoring of rolling element bearing, gears and tool condition monitoring techniques in machining.

UNIT- I

Chapter 1 : Introduction to maintenance and condition based maintenanceDefinition, system approach, objectives, responsibilities of maintenance department, maintenance strategies, principles of maintenance, concepts of maintainability, availability and reliability, implementation of CBM, comparison of CBM with other maintenance techniques and case studies (overview).

Chapter 2 : Introduction to condition monitoring Basic concept, techniques -visual monitoring, temperature monitoring, vibration monitoring, lubricant monitoring, crack monitoring, thickness monitoring, noise and sound monitoring.

UNIT- II

Chapter 3 : Basic signal processing techniques Probability distribution and density, Fourier analysis, Hilbert Transform, Cepstrum analysis, Digital filtering, Deterministic / random signal separation, Time-frequency analysis.

Chapter 4 : Wavelet Transform Introduction to Wavelets, Continuous Wavelet Transform (CWT), Discrete Wavelet Transform (DWT), Wavelet Packet Transform (WPT),types of wavelets –Haar wavelets, Shannon wavelets, Meyer wavelets, Daubechies wavelets, Coifmann wavelets and applications of wavelets.

UNIT –III

Chapter 5 : Vibration Monitoring Introduction, vibration data collection, techniques, instruments, transducers, selection, measurement location, time domain analysis, frequency domain analysis, time-frequency domain analysis and commonly witnessed machinery faults diagnosed by vibration analysis.

Chapter 6 : Rotating and reciprocating machines Vibration signals from rotating and reciprocating machines –signal classification, signals generated by rotating machines, signals generated by reciprocating machines.

UNIT - IV

Chapter 7 : Mechanical fault diagnosis ,Wear monitoring and lubricant analysis -sources of contamination, techniques, Spectrometric Oil Analysis Procedure (SOAP) and ferrography.

Chapter 8 : Nondestructive testing techniques Measurement of surface and subsurface flaws –liquid penetrant inspection, eddy current inspection, radiographic inspection, ultrasonic inspection.

UNIT - V

Chapter 9 : Condition monitoring of rolling element bearings and gear Introduction, construction, types of faults, rolling element bearing diagnostics and gear diagnostics.

Chapter 10 : Tool wear monitoring, Introduction, techniques and case studies.

Text Books

1. Robert Bond Randall –Vibration-Based Condition Monitoring –Industrial, Aerospace and Automotive applications, John Wiley & Sons Ltd., 2011
2. R.A.Collacot –Mechanical Fault Diagnosis –Chapman and Hall Ltd., 1977.
3. ISTE Course material on Condition Monitoring.
4. R.C.Mishra, K.Pathak –Maintenance Engineering and Management, Prentice Hall ofIndia Pvt. Ltd., 2002.
5. K.P. Soman, K. I. Ramachandran, N. G. Resmi –Insight into wavelet from theory to practice, Third Edition, Prentice Hall of India, ISBN: 978-81-203-4053-4

Reference Books

1. Dr. K.Balaveera Reddy, ISTE Summer School on Machinery Diagnostics and Preventive Maintenance, KREC, Surathkal, June 19-25, 1995.
2. Dr. A.Ramachandra, ISTE-STTP on Maintenance of Machinery, SJCE, Mysore, June 18-31, 2000.
3. John S.Mitchell, Introduction to Machinery Analysis and Monitoring, PennWell Books,1993.

VII Semester
Department of Mechanical Engineering

Course Code : MET498-5 **Course : Steam and Hydro Turbines (Open Elective-IV)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week **Total Credits : 03**

Course Objectives

1. To give an overall impression of various steam and hydro turbines used in the power industry.
2. To develop an ability to analyze different performance characteristics of steam and hydro turbines.

Course Outcomes

On completion of this course the students will be able to:

1. Understand the basic layout of steam power plants and components of steam turbines.
2. Identify different types of steam turbine and its performance parameters.
3. Investigate different components of steam power plant related to steam turbine
4. Understand basic layout of hydroelectric power plant and components of hydraulic turbines
5. Understand design considerations of different hydraulic turbines
6. Understand different performance parameters of hydraulic turbines.

Unit - I

Basic layout of steam power plant, vapor power cycle, Rankine cycle, Steam turbine principle of operation, types of steam turbines, Description of main components of steam turbine i.e. Turbine Casing, Rotor, Blades, Steam admission Valves, Couplings, Bearing, Barring Gear, Turbine Velocity Diagrams, Concepts of turbine Lubrication Oil System.

Unit - II

Compounding of steam turbines, impulse turbine–velocity diagram, calculation of work, power and efficiency, condition for maximum efficiency, Reaction turbines –velocity diagram, degree of reaction, reheat factor, governing of steam turbine–throttle, nozzle and bypass governing, Methods of attachment of blades to turbine rotor, Labyrinth packing, Losses in steam turbine

Unit - III

Turbine Gland Sealing System, steam condensation, cooling water (CW), cooling towers (CT), CW pumps and CT fans. Constructional details and working principles of condensate extraction pump, Boiler feed pump, clarified water pump, HP & LP Dozing pump, PA & IA Compressors with dryer. Concept of Turbine governing system.

Unit - IV

General layout of hydroelectric power plant, energy conversion and different components of hydroelectric power plant, Components of hydraulic turbines, classification and description of different turbine types, Standardization and selection of turbine.

Unit - V

Francis turbine runner design, design of axial turbine runner including bulb turbine, hydraulic calculations of spiral casing and guide wheel, draft tube theory, standardization and applications of draft rube, Pelton turbine design.

Unit - VI

Characteristic parameters of different hydraulic turbines: Cavitation and net positive suction head (NPSH), The speed number covering Kaplan-Francis and Pelton turbines, The reaction ratio, analysis for improvement of hydraulic design of turbines to avoid cavitation. Turbine control systems and regulating requirements of power plants

Text Books

1. P. K. Nag, "Power Plant Engineering", Tata McGraw Hill Publications.
2. R. Yadav, "Steam Turbine", Khanna Publishers.
3. "Steam Turbine and its Auxiliaries", Manufacturer s Power Plant Manual.

Reference Books

1. Krivchenko GI. Hydraulic machines: turbines and pumps. Lewis Publishers; 1994.
2. Rajmohan Gupta, "Steam Turbine", Oxford & IBH Publishing Co. Pvt. Ltd.
3. Hydraulic turbines Design, Erection and Operation by Hermod Brekke
4. Hydraulic Turbines-Their Design and Installationby Viktor Gelpke and A. H. Van Cleve

VII Semester
Department of Mechanical Engineering

Course Code : MEP455 **Course : Internship Evaluation**

L: 0Hrs., T: 0Hrs., P: 2Hrs., Per week **Total Credits : 00**

Course Objectives

The Objective of this course is to prepare the students

1. To become familiar with the actual working of industrial and business organizations and to identify the skills required for performing the jobs
2. To prepare themselves for the transition from campus to corporate and to become industry ready by acquiring the desired knowledge, skills and the attitude

Course Outcomes

At the end of this course students will demonstrate the ability to

1. Adapt with the work environment of the engineering and business organizations. Mould themselves in the work culture of the engineering and business organizations.
2. Relate and apply the engineering knowledge to the tasks at the workplace
3. Understand the role of engineers and expectations from engineers in the corporate world
4. Understand and practice the professional approach of working and follow ethical values. Communicate effectively with written, oral and visual means.

The students would undertake single or multiple Internships for a total period of minimum 6 weeks and extending upto 8 weeks during their Summer and Winter vacations in reputed manufacturing or business organizations before entering in the Seventh Semester.

During this internship the students would get acclimatized with the working conditions and the work culture of the various organizations. They will get exposure to the working of the industrial and business organizations and learn the practical side of the engineering and management knowledge.

They would have to submit an internship report along with an internship certificate from the respective organizations. The students would be evaluated through the presentations during their Seventh Semester.

VII Semester
Department of Mechanical Engineering

Course Code : MEP460 **Course : Project Phase - III**

L: 0Hrs., T: 0Hrs., P: 2Hrs., Per week **Total Credits : 05**

This course involves undertaking a dissertation or report on a topic consisting of design, experimental or analytical investigation by the group of students.

Course Objectives

1. Simulate a realistic working experience for students;
2. Provide them an experience of applying engineering principles, engineering economics, written and verbal communication skills
3. Train students to work independently and in team to obtain an effective and acceptable solution to industry-related or research-type problems

Course Outcomes

On successful completion of the course, the student will be able to,

1. Identify real world problems of mechanical engineering and related systems.
2. Interpret the working of mechanical engineering systems.
3. Apply the principles of mechanical engineering in real world systems with literature backup.
4. Criticize and experiment to arrive at solutions for real world mechanical engineering problems.
5. Analyse and evaluate to obtain solution for problems in mechanical engineering system

VIII Semester
Department of Mechanical Engineering

Course Code : MET461-1 **Course : Industrial Management and Entrepreneurship Development (Elective-VII)**

L: 3Hrs., T: 0Hrs., P: 3Hrs., Per week

Total Credits : 03

Course Objectives

The objective of the course is to prepare the students:

1. To learn the basics of industrial management and become familiar with the working of the industries
2. To develop understanding of entrepreneurship as a profession and hence to prepare them for a possible career in entrepreneurship

Course Outcomes

At the end of this course students will demonstrate the ability to

1. Get knowledge about the evolution of the management thoughts and the principles of scientific management
2. Understand the functions of Human resource management and the related legislations
3. Understand the concept of Production Planning and Control and Project Management
4. Get knowledge about entrepreneurship, traits and competencies for the same and the factors affecting entrepreneurial growth
5. Get knowledge about the ownership structures and the steps involved in setting up a business
6. Get overview of the marketing function and the various sources of finance

Syllabus

Unit - I

Principles and Functions of Management : Concepts of Management, Principles of Management by Frederick Taylor & Henry Fayol, Contributions of prominent Management Thinkers, Management functions – Viz, Planning, Organizing, Directing, Controlling Communicating, Decision Making, Leading, Motivating

Unit - II

Human Resource Management : Meaning, functions of Human Resource Management, manpower planning, training and development, wages & salary administration, collective bargaining, labor welfare, trade unions, Industrial Safety, Industrial Factories Act, Business Ethics, Corporate Social Responsibility

Unit - III

Production Planning & Project Management : Production Systems, Overview of Types of Production, Capacity Planning, Production Planning & Control, Project Management, Introduction to CPM, PERT

Unit - IV

Overview of Entrepreneurship : Introduction to Entrepreneurship, Entrepreneurial Functions, Personality Traits and Competencies of Entrepreneurs, Achievement, Motivation. Types of Enterprises, Ownership Structures, Factors Affecting Entrepreneurial Growth. Statutory agencies and government organizations in Industrial Sector, Role of Consultancy Organizations

Unit - V

Small Enterprises : Definition, Characteristics, Advantages and Limitations of SSI, Procedure to set up small scale Industries Unit, Project Formulation, Steps involved in setting up a Business, Preparation of Preliminary Project Reports, Project Appraisal, Techno Economic Feasibility Assessment

Unit - VI

Marketing & Finance : Overview of Marketing Function, 4 Ps of Marketing, Product Life Cycle, Factors Governing Product Selection, Market Survey and Research, Sales Forecasting, and Customer Relationship Management

Sources of Finance, Term Loans, Capital Structure, Financial Institutions, Management of working Capital, Costing, Break Even Analysis

Text Books

1. Chopde I.K. , Shaikh A.M., Industrial Management, S. Chand Publisher.
2. Khanna O. P, .Industrial Engineering & Management, Dhanpat Rai Publication, India.
3. Khanka S. S., Entrepreneurship Development:, S. Chand Publisher.

Reference Books

1. Harold Koontz & Cyril O Donnell, Principles of Management.
2. Sharma S.K., Industrial Engineering and Organizational Management, S.K. Kataria and Sons.
3. Bhattachcryya D.K., Industrial Management,Vikas Publishing House.
4. Singal R.K., Entrepreneurship and Development, S.K. Katariya and sons.

VIII Semester
Department of Mechanical Engineering

Course Code : MET461-2 **Course : Lean Production Systems (Elective-VII)**

L: 3Hrs., T: 0Hrs., P: 3Hrs., Per week **Total Credits : 03**

Course Objective

At the end of the semester the students should be have a basic understanding of the lean Manufacturing systems and be able to analyze, and optimize such systems.

Course Outcomes

At the end of this course the student will demonstrate ability to

1. Measure production performance and how defects and waste degrade performance.
2. Recognize the Just in time production system and its applications.
3. Understand the concept of KANBAN, TPM and OEE System to improve the production system.
4. Compute the standard time and explore the SMED technique.
5. Apply elements of Lean production including Heijunka, Jidoka, and Poka Yoke.
6. Apply the 5S methodology for establishing and sustaining a productive work environment.

Unit - I

Review the history of Lean Production, focusing on Japan's Toyota Production System as an alternative to mass production. Discuss how waste impacts productivity.

Unit - II

Just in time production system. JIT Logic –Pull system Japanese approach to production elimination of waste – JIT implementation requirements JIT application for job shops

Unit - III

The important concepts of cycle time and tact time. Understand the relationship between inventories, Kanban System: Kanban rules, supplier Kanban and sequence schedule used by supplier, Monthly information & daily information. Discuss the concept of Total Productive Maintenance and Overall Equipment Efficiency.

Unit - IV

Calculate the impact of setups on capacity when the product variety is increased and understand how batching can improve this, but at the expense of increased inventory. Review the Single Minute Exchange of Die (SMED), and learn why reducing setups and changeovers are critical to Lean manufacturing.

Unit - V

Understand how Poka Yoke can help fool-proof our processes and learn how to structure and concept of Kaizen for rapid improvement opportunities for problem-solving and process improvements. Understand the elements of Lean production including Heijunka, Jidoka.

Unit - VI

Introduction to the concepts of Workplace Visualization and Organization and 5S for improving and maintaining continuous flow in Lean Production. Value Stream Mapping- Understanding the current state and designing the future state managing lean enterprise.

Text Book

1. Industrial Engineering and Production Management by Martand Telsang, S.Chand & Company Ltd.
2. Lean Production Simplified by DENNIS, CRC Press, 2016.

References Books

1. The Toyota Way: 14 Management Principles From The World's Greatest Manufacturer By Jeffrey K. Liker

VIII Semester
Department of Mechanical Engineering

Course Code : MET461-3 **Course : Reliability Engineering (Elective-VII)**

L: 3Hrs., T: 0Hrs., P: 3Hrs., Per week **Total Credits : 03**

Course Objective

The objective of the course is to

1. Understand the important concepts used in system reliability
2. Gain insights about the tools and techniques used for determining system reliability.

Course Outcomes

At the end of this course the student will demonstrate ability to

1. Understand concepts and terminology in reliability.
2. Understand the applications of constant failure model and estimation of system reliability.
3. Perform failure analysis and construct fault tree diagram
4. Understand different maintenance strategies along with recent trends
5. Understand planning and scheduling in maintenance and maintenance effectiveness measurement
6. Explore the concept of maintenance effectiveness

Syllabus

UNIT - I

Introduction to reliability, analysis of downtime, concept of availability, random versus deterministic failure phenomena, terms and definitions in reliability, application areas, reliability function, MTTF, Hazard rate function, bath tub curve, conditional reliability.

UNIT - II

Constant Failure Rate (CFR) model- Failure modes with CFR model, two parameter exponential distribution, Poisson process, relevant applications. Reliability of systems – Series configuration, parallel configuration, and combined series parallel, redundancy, K out of N redundancy.

UNIT - III

Design for reliability : Failure analysis, identification of failure mode, determination of cause, assessment of effect, classification of severity, system safety and fault tree analysis.

UNIT - IV

Maintenance concept : Functions, objectives, purpose, system approach to maintenance function maintenance planning and scheduling – Steps in job planning, planning technique, job manual, scheduling, Gantt chart and bar chart, PERT/CPM and CPA network.

UNIT - V

Maintenance strategies : Basis of selecting maintenance strategies, types of maintenance, breakdown or emergency maintenance, preventive, predictive, condition-based maintenance, risk based maintenance, design out maintenance, comparison of maintenance strategies, total maintenance management.

UNIT - VI

Maintenance effectiveness : Overall equipment effectiveness, maintenance effectiveness assessment/ survey, Key performance indicators (KPI), maintenance performance measuring indices, maintainability index, Recent trends in maintenance - Reliability centered maintenance, Total productive maintenance.

Text Book

1. Reliability and Maintainability Engineering – Charles E. Ebeling, Tata McGraw Hill Edition.
2. Maintenance Engineering – Er Sushilkumar Srivastava, S Chand Publications 1998.

References Books

1. Reliability Engineering- L. S. Srinath affiliated East- west Press Private Limited
2. Reliability Engineering – E. Balagurusamy Tata McGraw Hill Publications

VIII Semester
Department of Mechanical Engineering

Course Code : MET462-1 **Course : Productivity Improvement Techniques**

L: 3Hrs., T: 0Hrs., P: 3Hrs., Per week **(Elective-VIII)**

Total Credits : 03

Course Objectives

The objective of the course is to prepare the students:

1. To understand and become conversant with the various techniques of organizational performance improvement
2. To improve the productivity and performance of the organizations by applying the various techniques

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Understand the various tools and techniques of productivity improvement.
2. Know the various techniques of work measurement and calculate the standard time
3. Become aware of the human factors in engineering in the context of man machine systems .
4. Understand the various types of plant layouts and know the principles of material handling
5. Use the concept of value engineering and be aware of other productivity improvement techniques
6. Understand the various types of maintenance and the concept of reliability and maintainability

Syllabus

Unit - I

Productivity& Work Study : Concept and objectives of Productivity, Types of Productivity, factors affecting Productivity. Tools & Techniques for Productivity Improvement, Measurement of Productivity. Omax Model.

Concept of work content, reasons for excess work content, Work study and Method study: Definitions, objectives, steps in method study, process charts, string diagram, motion study, micro motion study, SIMO Chart.

Unit - II

Work Measurement : Techniques of Work Measurement including Estimating, Stopwatch Time Study, Predetermined Time Standards, Synthetic Estimates of Work Times, MOST, Activity Sampling. Computation of Standard Time, Performance Rating, Allowances, Need for Allowances, Types of Allowances.

Unit - III

Ergonomics : Objectives, Human factors in Engg. Man machine system, Display design, design controls. Principles of motion economy, work place design. Human factors in Mechanization, Automation and Automated Systems, Anthropometry.

Unit - IV

Plant layout & Material Handling : Objectives, Principles, Types of plant layout, Material handling, Objectives, Principles and selection of material handling equipments, Unit load concept, material flow pattern. Materials management. Introduction to Supply chain management

Unit - V

Techniques for Improving Organisational performance : Value Analysis and Value Engineering. Introduction to 5S, Kaizen., Quality Circles, Quality Function Deployment, SMED, Lean manufacturing, Kanban,

Unit - VI

Maintenance Management : Objectives, Types of maintenance, preventive, predictive, break down maintenance. Reliability and maintainability analysis Failure data analysis, reliability, MTBT, MTTR, Bath tub curve, series parallel and stand by system.TPM

Text Books

1. Martand Telsang, Industrial Engg and Project management, S. Chand & Company Ltd.
2. Jain &Agrawal, Production Planning Control, Khanna Publisher.
3. McCormic, Sanders, Human Factors Engineering, McGraw Hill Publication.
4. Iyer S.S., Value Engineering, New Age International Publisher.
5. Manek N.J., Industrial Engineering, Laxmi Publications Pvt. Ltd.
6. Agrawal A.K., Plant Layout and Material Handling, Jain Publisher.

Reference Books

1. Work study by ILO, Oxford and IBH Publishing
2. R M Barnes, Motion and Time study, Wiley Press.
3. James Apple, Plant layout and Material Handling.
4. Dinesh Seth, Subhash C. Rastogi, Global Management Solutions.

VIII Semester
Department of Mechanical Engineering

Course Code : MET462-2 **Course : Field and Service Robots (Elective-VIII)**

L: 3Hrs., T: 0Hrs., P: 3Hrs., Per week **Total Credits : 03**

Course Objectives

The objective of the course is to familiarize the students with the various applications of Robots and to make them acquainted with the various theoretical aspects associated with it.

Course Outcomes

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

CO1: Explain basic terminology and various applications of industrial robots

CO2: Understand and describe the applications of aerial and space robot

CO3: Understand and describe the applications of underwater and mining robot

CO4: Understand and describe the applications of agriculture and construction robot

CO5: Understand and describe the applications of domestic and medical robot

CO6: Understand and describe the applications of humanoids and intelligent vehicles

Contents

Unit - I : Industrial Robotics

History and evolution of robotics, laws of robotics, robots, robot subsystems, robot configurations, classification of robots, Typical applications- welding, assembly, painting, automated material transfer, machining, human-robot cooperation for handling tasks

Unit - II : Aerial and Space Robotics

Introduction to aerial robotics, historical background, unmanned aerial vehicles, quad rotors, components of autonomous flight, applications and challenges of aerial robotics. Introduction to space robotics, historical background, surface robotic systems, applications and examples

Unit - III : Underwater and Mining Robotics

Introduction to underwater robotics, historical background, sensor systems, actuating systems, applications. Introduction to robotics in mining, historical background, applications in mining process

Unit - IV : Agriculture and Construction Robotics

Introduction to agricultural robotics, overview of the agricultural robots, typical applications, challenges in the field. Introduction to robotics in construction, system overview, basic types of construction robots, economic aspects, applications

Unit - V : Domestic and Medical Robotics

Introduction to home automation, domestic robotics, cleaning robots, lawn moving robots, challenges and applications. Introduction to medical robotics, historical background, surgical robots, rehabilitation robots, issues related to safety and ethics, applications and challenges in medical robotics.

Unit - VI : Humanoids and Intelligent Vehicles

Introduction to humanoids, historical background, locomotion and manipulation of humanoids, whole body activities, teaching methodologies, applications. Concept of intelligence, need and necessity of intelligent vehicles, driver assistance systems, driver monitoring systems, road scene interpretation, automated vehicles, applications and challenges

Reference Books

1. Industrial Robotics: Technology, Programming and Applications, by Groover M.P., Tata McGraw Hill Publication Ltd.
2. Underwater Robotics: Science, Design & Fabrication, by Moore S.W.,Bohm H., and Jensen V., Marine Advanced Technology Education (MATE) Center, 2010.
3. Aerial Robots: Aerodynamics, Control and Application, by Mejia O.D.M., Gomez J.A.E., (eds.), InTech Open Publications.
4. Robotics and Mechatronics for Agriculture, by Zhang D., Wei B., (eds.), CRC Press.
5. Medical Robotics, by Schweikard A., Ernst F., Springer Publications.
6. Household Service Robotics, by Xu Y., Qian H., and Wu X., Zhejiang University Press.
7. Springer Handbook of Robotics, by Khatib O., (ed.), Springer Publications.
8. Humanoid Robotics: A Reference, Vadakkepat P., Goswami A.,Springer Netherlands, 2017.
9. On Road Intelligent Vehicles, by Kala R., Elsevier Publications, 2017.

VIII Semester
Department of Mechanical Engineering

Course Code : MET462-3 **Course : Marketing Management (Elective-VIII)**

L: 3Hrs., T: 0Hrs., P: 3Hrs., Per week **Total Credits : 03**

Course Objective

The objective of this course is to enable students to understand basics of marketing function.

Course Outcomes

1. Understanding of basic concepts of marketing.
2. Ability to analyze consumer buying behavior and marketing research process.
3. Knowledge about segmentation, targeting and positioning.
4. Understanding of product management.
5. Ability to device pricing strategies and decide on distribution channels.
6. Understanding advertising and sales promotion

Unit - I : Introduction : Core concepts of marketing, nature and concept of marketing, marketing mix, service marketing, steps in the marketing process, nature and contents of marketing plan, understanding the marketing environment.

Unit - II : Consumer Behaviour : Consumer behaviour, buying decision process, organizational buying, customer relationship management, marketing research and demand forecasting.

Unit - III : Market Positioning : Market segmentation and targeting, positioning and repositioning; marketing strategies.

Unit - IV : Product Management : Meaning of product, product classification, product levels, product policies, product life cycle and new product development, product differentiation.

Unit - V : Pricing & Distribution : Pricing objectives, methods and pricing policies. Nature, functions, and types of distribution channels, Channel management decisions, Retailing and wholesaling

Unit - VI : Advetising and Sales Promotion : Understanding the communication process, Managing advertising, sales promotion, public relations and direct marketing, Social Media Marketing, Digital Marketing.

Text Book

1. Marketing Management-A South Asian Perspective: by Philip Kotler, Kevin Lane Keller, Prentice Hall

References Books

1. Marketing Management: by Rajan Saxena, Tata McGraw-Hill
2. Introduction to Marketing Management: by Adrian Palmer, Oxford University Press.

VIII Semester
Department of Mechanical Engineering

Course Code : MET463-1 **Course : Automation and Manufacturing (Elective-IX)**

L: 3Hrs., T: 0Hrs., P: 3Hrs., Per week **Total Credits : 03**

Course Objectives

The objective of the course is to prepare the students:

1. To understand automation knowledge and awareness of modern techniques in the automation field.
2. Thereby the students will get a comprehensive picture of Industrial automation and production line system.

Course Outcomes

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

1. Understand the automation knowledge, in terms of production line systems.
2. Analysis of automated flow line and line balancing techniques.
3. Understanding with CNC technology and its role in automation.
4. Familiarity with robotic areas, thereby achieve multidisciplinary integration.
5. Recognize material handling systems performance using analytical methods.
6. Apply manufacturing methodology to improve the manufacturing flexibility.

Syllabus

Unit - I

Automation : Definition, types, reasons for automating, Automation systems and strategies Types of production, Methods of work part transport, Transfer mechanisms, parts feeding devices, Production line terminology and analysis.

Unit - II

Analysis of flow lines : Analysis of transfer lines without storage, Storage buffer effectiveness, automated flow lines with storage buffers, Line Balancing: methods of line balancing and algorithms.

Unit - III

Numerical Control : NC Basic concepts, Machine control unit and NC components, Tape and tape readers, DNC and CNC, Types and classifications of NC systems, coordinate system and tool motion, NC part programming features, manual part programming, applications of NC.

Unit - IV

Industrial Robotics : Introduction, robot anatomy, robot control systems, accuracy and repeatability and other specifications, robot manipulator configurations, SCARA, wrist configurations, types of end effectors, types of sensors. Different types of robot applications, work cell layout, introduction to robot programming.

Unit - V

Automated material handling & storage : Conveyor systems, Automated Guided Vehicle Systems, Types, Vehicle guidance & Routing, Traffic control & safety, System management, Analysis of AGVS systems, Automated Storage & Retrieval System, Analysis of AS/ RS, Carousel storage systems.

Unit - VI

Group Technology, Part families, parts classification & coding, Opitz and Multiclass classification systems, Production flow analysis.

Flexible manufacturing systems : Components, FMS layout configuration data files, system reports, FMS planning and benefits.

Automated inspection and types, Coordinate measuring machine, Machine vision system.

Text Books

1. Automation, production System & CIMS: M. P. Groover, Prentice Hall of India, New Delhi
2. Industrial Robotics: M. P. Groover, Roger N. Nagel, Mc Grow-Hill, New Delhi
3. CNC Machines: M. Adithan& B. S. Pabla, New Age International Publications New Delhi

Reference Books

1. CAD/CAM: M. Groover& E. Zimmers , Pearson Education, Delhi
2. Industrial Engg. & Production Management : Martand Telsang, S. Chand Publications, Delhi
3. Computer Control of Manufacturing Systems: Yoram Koren, Mcgraw Hill, Delhi

VIII Semester
Department of Mechanical Engineering

Course Code : MEP463-1 **Course : Automation and Manufacturing Lab (Elective-IX)**

L: 0Hrs., T: 0Hrs., P: 2Hrs., Per week **Total Credits : 01**

Course Objectives

The objective of the course is to prepare the students:

1. To be familiar with the modern methods and techniques in the automation field.
2. To understand CNC and CMM technology through various machines available.

Course Outcomes

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

1. Understand the knowledge of automation in terms of AFL analysis.
2. Understand the line balancing algorithms for station formations and logics.
3. Familiarity with industrial robotic, thereby study its components, programming.
4. To study and analyze the material handling systems and group technology concept.
5. Learning of CNC and CMM technology through various machines available.

List of experiments based on following topics:

Expt 1: To study automated flow line (AFL) & transfer line mechanism.

Expt 2 : To Study Line Balancing Algorithms.

Expt 3 : To study robot basic components and different robot configurations.

Expt 4 : To study the methods of programming and applications of robots.

Expt 5 : Performance on Coordinate Measuring Machine (CMM)

Expt 6 : To study automated material handling and storage systems.

Expt 7 : To study Group Technology.

Expt 8 : To study NC component and Program of instructions.

Expt 9 : To perform CNC - Lathe Programming.

Expt 10. To perform CNC - Milling Programming.

Text Books

1. Groover M. P., Automation, production System & CIMS:, Prentice Hall of India, New Delhi.
2. Groover M. P., Roger N. Nagel, Industrial Robotics, Mcgraw-Hill, New Delhi.
3. M. Adithan & B. S. Pabla, CNC Machines, New Age International Publications New Delhi.

Reference Books

1. M. Groover & E. Zimmers, CAD/CAM, Pearson Education, Delhi.
2. Martand Telsang, Industrial Engg. & Production Management, S. Chand Publications, Delhi.
3. Yoram Koren, Computer Control of Manufacturing Systems, Mcgraw Hill, Delhi.

VIII Semester
Department of Mechanical Engineering

Course Code : MET463-2 **Course : Product Life cycle Management (Elective-IX)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week **Total Credits : 03**

Course Objectives

This course will train the students on latest technologies such as PLM/PDM, by going through this course they will be able to implement and develop such systems required by the industries in this competitive age.

The objective of the course is to prepare the students:

1. Understand the various strategies of PLM, concept of product design, development, simulation and support system
2. Interpret the technology forecasting, product innovation, product building & configuration and apply in business processes.

Course Outcomes

At the end of this course, students will demonstrate the ability to

1. Explain the various strategies of PLM and Product Data Management
2. Describe decomposition of product design and model simulation
3. Apply the concept of New Product Development and its structuring.
4. Analyze the technological forecasting and the tools in the innovation.
5. Apply the virtual product development and model analysis
6. Administer for installing, configuring, integrating and efficient management of PLM tools.

Syllabus

UNIT - I : Introduction to PLM and PDM

Introduction to PLM, Need for PLM, opportunities and benefits of PLM, different views of PLM, components of PLM, Design Thinking, PLM feasibility study. PLM Strategies, strategy elements, its identification, selection and implementation. Product Data Management, implementation of PDM systems.

UNIT - II : Product Design

Engineering design, organization and decomposition in product design, product design process, Management of product data interfaces, GD&T, annotations, manufacturing notes, Integration of CAM with PLM. PLM methodical evolution in product design, concurrent engineering, design for„ X" and design central development model. Strategies for recovery at end of life, recycling, human factors in product design. Modelling and simulation in product.

UNIT - III : Product Development

New Product Development, structuring new product development, building decision support system, estimating market opportunities for new product, new product financial control, implementing new product development, market entry decision, launching and tracking new product program. Concept of redesign of product.

UNIT - IV : Technology Forecasting

Technological change, methods of technology forecasting, relevance trees, morphological methods, flow diagram and combining forecast of technologies Integration of technological product innovation and product development in business processes within enterprises, methods and tools in the innovation process according to the situation, methods and tools in the innovation process according to the situation.

UNIT - V : Product Building and Structures

Virtual product development tools for components, machines, and manufacturing plants: 3D CAD systems, digital mock-up, model building, model analysis (FEA), production (process) planning, and product data technology, Product structures: Variant management, product configuration, material master data, product description data, Data models, Life cycles of individual items, status of items. Introduction to augmented reality, Digital twin and IOT

UNIT - VI : PLM Implementation

Activities Involved under various phases of PLM implementation like Pre-Align, Align, Plan, Build (Additive & Subtractive Manufacturing), Test, Deploy and Close.

Text Books

1. Stark, John. Product Lifecycle Management: Paradigm for 21st Century Product Realisation, Springer-Verlag, 2004. ISBN 1852338105
2. Fabio Giudice, Guido La Rosa, Product Design for the environment-A life cycle approach, Taylor & Francis 2006

Reference Books

1. Saaksvuori Antti / Immonen Anselmie, product Life Cycle Management Springer, Dreamtech, 3540-25731-4
2. Product Lifecycle Management, Michael Grieves, Tata McGraw Hill
3. Kari Ulrich and Steven D. Eppinger, Product Design & Development, McGraw Hill International Edns, 1999.

VIII Semester
Department of Mechanical Engineering

Course Code : MEP463-2 **Course : Product Life cycle Management Lab (Elective-IX)**

L: 0Hrs., T: 0Hrs., P: 2Hrs., Per week **Total Credits : 01**

Course Objectives

Data management is the key issue for the OEM and designers, so through this lab course student will enhance their ability to develop and implement general PLM procedure.

The objective of the course is to prepare the students:

1. Demonstrate various functions of the PDM and PLM tools.
2. Provide opportunity to enhance skills needed in domain of PLM.
3. Impart use of various applications of CAD and PLM tools.

Course Outcomes

At the end of course, students will able to;

1. Express design thinking skills.
2. Create a geometrical model.
3. Analyze the FE Model through CAE tools.
4. Optimize the design for manufacture.
5. Realize the Product.

List of Practicals

1. Design Thinking for a product idea, setting up the objectives, methodologies and expected application services. Sketch (Optional clay modelling, silicone moulds, 3-D scanning)
2. Designing the product through CAD software (Catia V6), geometrical modelling, check for interference. Animation and basic drafting
3. Virtual verification and validation through Finite Element Analysis (MSC Patran& Nastran) of the product
4. Optimization for shape, size, weight considering Design for Manufacture
5. Part, Production (GD&T), Assembly drawing with BoM
6. Prototype Manufacturing (3-D Printing, CNC machining, welding)
7. Factory Magix software, BoM generation & Management
8. Manufacturing Execution system demonstration
9. Extended learnings on Digital Twins, AR, VR, Vuforia etc

VIII Semester
Department of Mechanical Engineering

Course Code : MET463-3 **Course : Human Factors Engineering (Elective-IX)**

L: 3Hrs., T: 0Hrs., P: 0Hrs., Per week **Total Credits : 03**

Course Objectives

The objective of the course is

1. Learn about different ergonomic principles that go into the design of products and process.
2. Discover about different techniques that are used for identifying, preventing and managing work related stress cases.

Course Outcomes

At the end of this course the student will demonstrate ability to

1. Understand an expanded view of ergonomics
2. Recognize the concept of anthropometry.
3. Get the insight of cognitive Ergonomics.
4. Acknowledge the importance of human physiology at workplace.
5. Apply the ergonomics concept in Visual Terminal Displays and Controls.
6. Explore the Biomechanics and NIOSH.

Syllabus

Unit - I

Introduction to Ergonomics : Scope, applications. Productivity Correlation, Human

machine System Principles of Ergonomics, Process and application of Ergonomics, Research Design and Evaluation Methods

Unit - II

Engineering Anthropometry and Work Space Design : Structural and functional dimensions, collection of anthropometric principles in application of anthropometric data. Design of workplace, seat design

Unit - III

Cognitive Ergonomics : Concept of information, human information processing model, memory, Problem solving and troubleshooting, Meta Cognition and Effort

Unit - IV

Work Physiology : Metabolism & heat regulation, Muscle Structure, energy cost of work load, physical work capacity, whole body fatigue, stresses and work load.

Unit - V

Physical Ergonomics Visual Sensory system, Auditory, Tactile and Vestibular systems, Noise, Illumination, Heat, Design of Displays and Controls

Unit - VI

Biomechanics of Work Musculoskeletal System, Bio Mechanical Models, Low Back Problem, NIOSH, Cumulative Trauma Disorder

Text Books

1. Human factors Engineering & Design - Mark S. Sanders. Ernest J. Me McCormick: McGraw Hill International Edition 30th September 1992 7th Edition

Reference Books

1. Ergonomics: Man, in his working Environment-Murrell, K.Chapman and Hall London1980 1st Edition
2. Human Factors Design Handbook-Wooden Vs. McGraw Hill New York 2nd Edition
3. R. S. Bridger, "Introduction to Ergonomics", CRC Press.

VIII Semester
Department of Mechanical Engineering

Course Code : MEP463-3 **Course : Human Factors Engineering Lab (Elective-IX)**

L: 0Hrs., T: 0Hrs., P: 2Hrs., Per week **Total Credits : 01**

Course Objectives

The objective of the course is

1. Apply ergonomic principles for identifying work related problems/cases in Industry.
2. Identify Occupational Hazards arising out of improper design.

Course Outcomes

At the end of this course the student will demonstrate ability to

1. Design work systems and products using Anthropometric data.
2. Identify poor performance effects due to environmental factors.
3. Understand assignment of work load and its relation with physiological parameters.
4. Investigate Occupational hazards related to improper working condition and design workplace ergonomically.

List of Practicals

The experiments would be based on following topics

- Measurement and Interpretation of Illumination
- Measurement and Interpretation of Noise Level
- Estimation of Physical Work Capacity [PWC], Energy Expenditure and Oxygen Consumption Using Bicycle Ergo Meter
- Determination of Physiological Cost of Walking and Physiological Cost Index of walking (PCI) Using Heart Rate
- Experiment On "Spirometry" The Classic Pulmonary Function Test.
- Determination of Body Mass Index (BMI), and Calculations of Basal Metabolic Rate (BMR) and Resting Metabolic Rate (RMR)
- Determination of Speech Transmission Index (STI) as a function of Background noise dB (A)
- Seminar: Presentations on Research Papers from Journals, Relevant to the scope of Scheme

VIII Semester
Department of Mechanical Engineering

Course Code : MEP470 **Course : Project Phase - IV / Industry Project**

L: 0Hrs., T: 0Hrs., P: 12Hrs., Per week **Total Credits : 06**

Course Objectives

1. Simulate a realistic working experience for students;
2. Provide them an experience of applying engineering principles, engineering economics, written and verbal communication skills
3. Train students to work independently and in team to obtain an effective and acceptable solution to industry-related or research-type problems

Course Outcomes

On successful completion of the course, the student will be able to,

1. Identify real world problems of mechanical engineering and related systems.
2. Interpret the working of mechanical engineering systems.
3. Apply the principles of mechanical engineering in real world systems with literature backup.
4. Criticize and experiment to arrive at solutions for real world mechanical engineering problems.
5. Analyse and evaluate to obtain solution for problems in mechanical engineering system

This course involves undertaking a dissertation or report on a topic consisting of design, experimental or analytical investigation by the group of students.

VIII Semester
Department of Mechanical Engineering

Course Code : MEP471 **Course : Full Semester Internship**

L: 0Hrs., T: 0Hrs., P: 0Hrs., Per week **(Research / Industry / TBI)**

Total Credits : 16

Course Objectives

The Objective of this course is to prepare the students

1) To get acclimatized with the environment and working of manufacturing/ service industry
2) To enhance the employability by getting the first hand experience of role of a Mechanical Engineer at the job.

Course Outcomes

1. At the end of this course students will demonstrate the ability to
2. Adapt to the environment and working of the industry and safety practices
3. Understand the correlation between theoretical concepts and their practical implementation
4. Deal with the Trans disciplinary/ interdisciplinary nature of the real world problems
5. Apply the engineering knowledge and skills for solving the problems
6. Develop the supervisory, managerial and professional skills and ethical values
7. Become conversant with all forms of business communications and presentations

The internship scheme will be governed by the directions of the Academic Council and the guidelines issued by Dean Academic for the conduction and evaluation of the performance of the students.

The students who would opt for the Full Semester Internship will have to carry out the same in a reputed manufacturing or service organization. The broad criteria for choosing the appropriate organizations will be that those organizations which can/ do employ the Mechanical Engineers may be considered as acceptable. The internship may be arranged through college T & P Dept/ or by students themselves. If the students arrange the internship on their own the T & P Department/ Parent Department may verify and get satisfied about the credentials of the organization. The internship will also include the internships offered by the College in research, entrepreneurship etc

During this internship the students would get a better practical exposure of the working of the industry and can handle some responsibilities and tasks given by the industry which may not be possible during short duration trainings. The students will be required to maintain a log of their work assignments and submit an Internship report towards the end of the Internship. They would have to also submit an internship completion certificate from the respective organization.

IV Semester (Honors Specialization)
Department of Mechanical Engineering

Course Code : METH41 **Course : Digital Manufacturing**

L: 4 Hrs. T: 0 Hrs. P: 0 Hrs. Per week **Total Credits : 04**

Course Objectives

1. To create, slice, 3-D print the parts and post process it if required.
2. To understand the subtractive manufacturing and microfabrication (MEMS)

Course Outcomes

Upon successful completion of the course, student should be able to:

1. To understand basic Conventional and Modern Machining Processes and Advanced Materialand their properties.
2. Students should able to understand the 2D and 3D Machining operations and Manual CNC Programming.
3. Model machine component using geometric modeling software, & Interpreter software.
4. Understand the Subtractive technology/ Additive Manufacturing.
5. Understand the Micro fabrication process MEMS
6. Understand the Micro fabrication process & Thin film deposition for MEMS

Unit - I : Overview of digital manufacturing processes

and Material properties: What makes a manufacturing process “digital”, The 10 disruptive principles of digital manufacturing processes. And Mechanical properties of printed materials, Post processing, Empirical and data- driven models (Polymers, Metals, Ceramics, and Resins).

Unit - II : CNC Machining and Programming

2D Lathe machining and different operations, 3D Milling machining and different operations.

Unit - III : CAD / CAM Modeling and Machine control

Design process and role of CAD, Types and applications of design models, Solid modeling - Parametric modeling, CAM Feature, Tool path generation for Lathe and milling operation. STL file generation; file verification & repair, STL/AMF Slicing CURA / Ultimaker, preprocessing and postprocessing techniques

Unit - IV : Additive Manufacturing processes

Liquid based processes, Powder based processes & Solid based processes, RP Processes: Process overview, Direct digital tooling, direct digital manufacturing, system classification, Stereo lithography, SL with photo polymerization, SL with liquid and thermal polymerization, Selective laser Sintering, Fused deposition modeling, Laser Powder forming.

Unit - V : Micro Fabrication Processes and Materials for MEMS

Substrate and wafers, Silicon as Substrate material, crystal structure, single crystal and polycrystalline, Mechanical properties, Silicon compound, silicon piezo- registers, gallium arsenide, quartz, Poezo-electric crystals, Polymers and Packaging materials. Fabrication Processes:- Bulk and Surface micro manufacturing, Photolithography, photo resists, structural and sacrificial material, x-ray and electron beam lithography.

Unit - VI : Thin film deposition for MEMS

Spin coating, thermal oxidation, chemical vapour deposition (CVD), Electron beam evaporation, sputtering, Etching- Wet etching and Dry etching, Wafer bounding- glass-frit, anodic fusion bonding, LIGA Process and applications.

Text Books

1. "Fundamentals of Digital Manufacturing Science" by Zhou, Zude, Xie, Sheng, Chen, Dejun,eBook, Springer publication ISBN 978-0-85729-564-4
2. "CNC Technology and Programming",Tilak Raj,Dhanpat Rai Publication Company.
3. "Micro and Smart Systems", G. K. Anantsuresh. K.j.Binoy, Willey India.

Reference Books

1. Rapid Manufacturing: An Industrial Revolution for the Digital Age – Editors N. Hopkinson, R.J.M. Hague and P.M. Dickens, (2006) John Wiley & Sons, Ltd., ISBN-10 0-470-01613-21. T. A. Grimm & Associates, Users Guide to Rapid Prototyping, Society of Manufacturing Engineers (SME) ISBN 0872636976
2. Frank W. Liou, Rapid Prototyping & engineering applications, CRC Press, ISBN 978- 0-8493-3409-2
3. Rapid Prototyping theory & practice, Manufacturing System Engineering Series, Ali K. Kamarani, Springer Verlag
4. Rapid Prototyping- case book, J. A. McDonalds, C. J. Ryall, Wiley Eastern
5. "Computer Numerical Control",Jon Stenerson and Kelly Curran, Prentice-Hall of India Pvt. Ltd.New Delhi, 2008

V Semester (Honors Specialization)
Department of Mechanical Engineering

Course Code : METH51 **Course : Tool Design**

L: 4 Hrs. T: 0 Hrs. P: 0 Hrs. Per week **Total Credits : 04**

Course Objectives

1. To provide comprehensive understanding of various design parameters required for tool design.
2. Enable the students to design provides specific tools.

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Understand basic principle of the metal cutting.
2. Describe design criterion for designing single point and multipoint cutting tools.
3. Understand press working operations in die design.
4. Understand working of bending, forming and drawing dies.
5. Describe forging die design and mould design.
6. Understand the principles of clamping, jigs and designing fixtures for machining.

Syllabus

UNIT - I

Theory of metal Cutting: Introduction, Mechanics of chip formation, Cutting tool

materials, Single point cutting tool, Designation of cutting tools, ASA system, Importance of Tool angles, Orthogonal rake system, Classification of cutting tools, Types of chips, determination of shear angle, velocity relationship, force relations, Merchant's Theory, Cutting power, Energy consideration in metal cutting, Tool wear, Tool life, Tool life criteria, variable affecting tool life, Machinability. (7)

UNIT-II

Design of single Point Cutting Tool: Form tools- Introduction, Types, design of form tools. Drills- Introduction, Types, Geometry, Design of drill.

Milling cutters - Introduction, Types, Geometry, and Design of milling cutters. (6)

UNIT-III

Introduction, Press operations - Blanking, piercing, Notching, Perforating, Trimming, Shaving, Slitting, Lancing, Nibbling , Bending, Drawing , Squeezing . Press working equipment - Classification, Rating of a press, Press tool equipments, arrangement of guide posts . Press selection, press working terminology, Working of a cutting die , Types of dies.

Principle of metal cutting, clearance, angular clearance, cutting forces, method of reducing cutting forces, Die block, Die block thickness, Die opening, Fastening of die block, back up plate, Punch, Methods of holding punches, Blanking & Piercing die design - Single & progressive dies. (7)

UNIT-IV

Bending Forming & Drawing dies, Bending methods - Bending Terminology, V- Bending, Air bending, bottoming dies, Wiping dies, spring back & its prevention, channel dies.

Forming Dies- Introduction, Types - solid form dies, pad type form dies, curling dies, Embossing dies, coining dies , Bulging dies, Assembly dies.

Drawing Dies - Introduction, Difference between blending, forming & drawing, Metal flow during drawing and design considerations. (7)

UNIT-V

Forging Die Design & mould Design: Introduction, Classification of forging dies, Single impression dies, Multiple Impression dies and Forging design factors.

Preliminary forging operation - fullering, edging, bending, drawing, flattering, blacking finishing, cutoff. Die design for machine forging in closed & open die forging, materials of forging dies .

Mould Design: of Simple Blow Moulds for Articles such as bottles, cans Design of simple two plate injection moulds , Mould Materials. (6)

UNIT-VI

Design of jigs & fixture :- Introduction, locating & clamping - principle of location, principle of pin location, locating devices, radial or angular location, V - location, bush location. Design principle for location purpose, principle for clamping purposes, clamping devices, design principles common to jigs & fixtures. Drilling Jigs:- Design principles, drill bushes, design principles for drill bushings, Types of drilling jigs.

Milling Fixtures:- Essential features of a milling fixtures, milling machine vice, Design principles for milling fixtures. (7)

Text Books

1. Production Engineering ,P.C. Sharma, S. Chand Publication
2. Tool Design, Donaldson, Tata McGraw Hill, New Delhi
3. Jigs and Fixtures, Joshi, Tata McGraw Hill, New Delhi.

Reference Books

1. Fundamentals of the Tool Design, ASTME, Prentice-Hall of India Private Ltd., New Delhi.
2. Manual of Jigs and Fixtures Design, Henrickson, Industrial Press Inc., New York.
3. Theory and Application of Metal Cutting, Juneja, Wiley Eastern Ltd., New Delhi.

VI Semester (Honors Specialization)
Department of Mechanical Engineering

Course Code : METH61 **Course : Turbo Machinery**

L: 4 Hrs. T: 0 Hrs. P: 0 Hrs. Per week **Total Credits : 04**

Course Objectives

1. To learn and understand principle of working and application of rotary compressors, gas turbines and combustion systems.
2. To provide the student the necessary and analytical skills to analyze steam power cycles alongwith steam nozzles and steam turbines.

Course Outcomes

Students will be able to

1. Apply thermodynamic concepts to understand the working of turbo machines.
2. Differentiate ideal and practical gas turbine cycles.
3. Understand the working of compressors and analyze their performance.
4. Understand the gas turbine combustion system.
5. Analyze the steam power plant cycles.
6. Design steam nozzles and steam turbines.

Syllabus

Unit I :

Review of Basics: Introduction to Prime Movers, Gas Turbines, Review of Basic principles - Thermodynamics, Review of Basic principles - Fluid Dynamics and Heat Transfer, Fundamentals of Rotating Machines - Energy Equation, Dimensional Analysis, Airfoil Theory.

Unit II :

Ideal Gas Turbine Cycles: Analysis of Ideal Gas Turbine Cycles, Simple Cycle, Regeneration Cycle, Reheat Cycle, Inter cooling Cycle. Practical Gas Turbine Cycles: Analysis of Practical Gas Turbine Cycles, Methods of accounting for component losses, changes in the composition of the working fluid. Working of Turbojet, Turbofan, Turboprop, Ramjet, Scramjet and Pulsejet Engines and cycle analysis –thrust, specific impulse, specific fuel consumption, thermal and propulsive efficiencies.

Unit III :

Centrifugal Compressors: Centrifugal Compressors- Principle of Operation, T-s diagram, Energy equation, velocity triangles, types of blades. Analysis of flow, Performance characteristics.

Axial Flow Compressors: Axial Flow Compressors - Construction, Principle of Operation, T-s diagram, Energy equation, velocity triangles. Analysis of flow. Work done factor, Stage efficiency, Degree of reaction, Performance characteristics.

Unit IV :

Combustion Chambers: Gas turbine combustion systems - Introduction, Geometry, Factors affecting Design & Performance, Requirements of the Combustion Chamber, Gas Turbine Combustion Emissions.

Unit V :

Rankine Cycle: Properties of Pure Substances, Property diagrams, Steam Power plant Layout, Rankine Cycle- Analysis, Modified Rankine Cycle, and Combined Cycle.

Unit VI :

Steam Nozzles: Steam Nozzles- Introduction, Area- velocity relationship, Mass flow rate, Choking of Nozzles, Performance characteristics of Nozzles.

Steam Turbines: Steam Turbines - Impulse and Reaction Turbines, Compounding of steam turbines, Multistage reaction Turbines, Reheat factor and Efficiency.

Text Books

1. Ganesan, V., Gas Turbines , Tata McGraw Hill Book Company, New Delhi, 2011.
2. Vasandani, V.P. and Kumar, D.S., Treatise on Heat Engineering, Chand and Co Publishers, New Delhi, 2011.
3. Saravanmuttoo, H.I.H., Rogers, G.F.C. and Cohen H., Gas Turbine Theory, Pearson Prentice Education, 2008.

Reference Books

1. Khajuria P.R and Dubey S.P, Gas Turbines and Propulsive Systems, Dhanpat Rai Publications, 2003
2. Hill P G and Peterson C R, Mechanics and Thermodynamics of Propulsion, Addition- Wesley, 1970.
3. Mattingly J D, Elements of Gas turbine Propulsion, McGraw Hill, 1st Edition. 1997

VII Semester (Honors Specialization)
Department of Mechanical Engineering

Course Code : METH71 **Course : Design of Heat Exchangers**

L: 4 Hrs. T: 0 Hrs. P: 0 Hrs. Per week **Total Credits : 04**

Course Objectives

To understand the thermal analysis and basics of heat exchanger design for different applications.

Course Outcomes

1. Understanding Classifications & Applications of Heat Exchangers.
2. Apply Principles of Fluid Mechanics & Heat Transfer to the Design of Heat Exchanger.
3. Understanding the Basic Design Aspects of Heat Exchangers.
4. Understanding the Design of Shell & Tube Heat Exchangers.
5. Understanding the Selection Criteria & Maintenance of Industrial Heat Exchangers.
6. Understanding of Design Considerations & Performance Enhancement Techniques for Practical Heat Exchangers.

Syllabus

Unit I :

Classification of Heat Exchangers, Constructional Details of Shell & Tube Heat Exchangers, Counter Flow Exchanger & Parallel Flow Exchanger, Industrial applications.

Unit II :

Fluid & Heat Transfer Aspects, Basic Thermal Design: LMTD Method, LMTD Correction Factor, Effectiveness of Heat Exchanger, Heat Capacity Rate Ratio, - NTU Method.

Unit III :

Heat Exchanger Design Methodology, Process and Design Specifications, Thermal, Hydraulic & Mechanical Design, Manufacturing Considerations, Heat Exchanger Design Sheets.

Unit IV :

Design of Shell & Tube Heat Exchanger: Preliminary Analysis, Sizing Analysis, Rating Program, Kerns Method, Pressure Drop Analysis.

Unit V :

Selection of Heat Exchangers & their Components, Selection Criteria Based on Operating Parameters, Operating Pressures and Temperatures, General Selection Guidelines for Major Exchanger Types, Quantitative Considerations, Fouling and Corrosion, Testing & Maintenance.

Unit VI :

Heat Exchanger Surface Geometrical Characteristics, Design Considerations for Tube-Fin Heat Exchangers, Plate-Fin Heat Exchangers, Condensers, Evaporators, Cooling Tower, Compact Heat Exchangers etc. Heat Transfer Enhancement Techniques.

Text Books

1. Fundamentals of Heat Exchanger Design Ramesh K. Shah, Dusan Sekulic, John Wiley & Sons Ltd.
2. Heat Exchanger Design, P. O. Fraas, John Wiley & Sons, 1988
3. Process Heat Transfer, Donald Q. Kern, McGRAW Hill Book Company

Reference Books

1. Heat Exchangers: Theory & Practices, T. Taboreck, G. F. Hewitt & N. Afgan, TMH,1980
2. Industrial Heat Exchanger: A Basic Guide, Walkar, TMH Book co,1980
3. Heat Exchangers: Basics Design Applications, Edited by Jovan Mitrovic, InTech Publisher
4. Tubular Exchanger Manufacturers Association, Manual

VIII Semester (Honors Specialization)
Department of Mechanical Engineering

Course Code : METH81-1 **Course : Tribology**

L: 4 Hrs. T: 0 Hrs. P: 0 Hrs. Per week **Total Credits : 04**

Course Objectives

1. Differentiate between the types of lubricants and its application area.
2. Understand behaviour of bearing and select the type of bearing for any given engineering use.

Course Outcomes

After successful completion of this course, students will be able

1. To know about properties of lubricants, modes of lubrication, additives etc.
2. To select suitable/proper grade lubricant for specific application.
3. To select suitable material combination for tribological contact.
4. To apply the basic theories of friction, wear and lubrications about frictional behavior commonly encountered sliding surfaces.
5. To suggest an explanation to the cause of tribological failures.
6. To design bearing, friction, wear test rig for laboratory purposes.

Unit 1: (8 hrs)

Tribology in design - bearing material its properties and construction Tribological design of oil seals and gasket. Tribology in industry (Maintenance).

Basic modes of lubrication, properties of lubricants, additives, EP lubricants, Recycling of used oil, oil conservation, oil emulsion.

Bearing Terminology -Types of Sliding contact, rolling contact bearings. Comparison between sliding and rolling contact bearing. (Theoretical treatment only)

Unit 2: Friction and wear (8 hrs)

Friction- classification, causes of friction, Theories of dry friction, Friction measurement, Stick-slip motion and friction instabilities.

Wear - classification, wear between solids, wear between solid and liquids, factors affecting wear, Theories of wear, Wear measurement.

Approaches to friction control and wear prevention.(Numericals)

Unit 3: Hydrodynamic lubrication (10 hrs)

Theory of hydrodynamic lubrication, mechanism of pressure development in oil film. Two dimensional Reynold's equation and its limitations, Petroff` 's equation.

Infinitely long journal bearing, infinitely short journal bearing and finite bearing, Designing journal bearing using Raimondi and Boyd approach. Hydrodynamic thrust bearing-Introduction, types.

Flat plate thrust bearing-Pressure equation, load, centre of pressure, frictional force equation.

Tiltling pad thrust bearing – bearing-Pressure equation, load, centre of pressure, frictional force equation.(Numericals on Raimondi and Boyd approach and thrust bearing only)

Unit 4: Hydrostatic lubrication (8 hrs)

Hydrostatic lubrication- viscous flow through rectangular slot, load carrying capacity, flow requirement of hydrostatic step bearing, energy losses, optimum design of stepped bearing, compensators and their actions. Squeeze film lubrication-Basic concept, circular and rectangular plate approaching a plane (Numericals on hydrostatic bearing, Squeeze film lubrication).

Unit 5: Elasto hydrodynamic lubrication and Gas (Air) lubrication (8 hrs)

Elasto - hydrodynamic lubrication-Principle and applications, pressure viscosity term in Reynold's equation, Hertz theory, Ertel - Grubin equation, lubrication of spheres.

Gas(air) lubricated bearings-Introduction, advantages, disadvantages, applications of tilting pad bearing, hydrostatic and hydrodynamic bearing with air lubrication, Active and passive magnetic bearings(working principle, types and advantages over conventional bearing).(Theoretical treatment only)

Unit 6: Tribological Aspects

Lubrication in rolling, forging, drawing and extrusion.

Mechanics of tyre road interaction, road grip, wheel on rail road.

Surface engineering for wear and corrosion resistance-diffusion, plating and coating methods, selection of coatings, properties and parameters of coatings.

Other bearings-porous bearing, foil bearing, Lobe, hybrid bearing.(Theoretical treatment only)

Text Books

1. Principles and Applications of Tribology, Bharat Bhushan, 2ndEdition, Wiley India
2. Introduction to Tribology and Bearings, Mujumdar B. C., S. Chand and Company Ltd., New Delhi.

Reference Books

1. Fundamentals of Tribology, R. Gohar and Homer Rahnejat, Imperial College Press, London.
2. Engineering Tribology, G.W. Stachowiak & A. W. Batchelor, Elsevier Science Publisher, Amsterdam

VIII Semester (Honors Specialization)
Department of Mechanical Engineering

Course Code : METH81-2 **Course : Robotics**

L: 4 Hrs. T: 0 Hrs. P: 0 Hrs. Per week **Total Credits : 04**

Course Objectives

To understand the basic concepts associated with the design, functioning and applications of robots.

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Understand the basic of Robotics.
2. Understand the functional elements of Robotics.
3. Understand the direct and inverse kinematics solution for manipulator
4. Understand the velocity analysis of manipulator
5. Understand the dynamic analysis of serial manipulator
6. Understand the Motion planning and control.

Syllabus

Unit 1 : Introduction :

Brief history- Types of Robot–Technology-Robot classifications and specifications -Design and Control issues -Various manipulators –Sensors -work cell -Programming languages.

Unit 2: Elements of robots -- joints, links, actuators, and sensors :

Position and orientation of a rigid body, Homogeneous transformations, Representation of joints, link representation using D-H parameters, Examples of D-H parameters and link transforms, different kinds of actuators – stepper, DC servo and brushless motors, model of a DC servo motor, Types of transmissions, Purpose of sensors, internal and external sensors, common sensors – encoders, tachometers, strain gauge based force-torque sensors, proximity and distance measuring sensors, and vision.

Unit 3: Kinematics of serial robots :

Introduction, Direct and inverse kinematics problems, Examples of kinematics of common serial manipulators, workspace of a serial robot, Inverse kinematics of constrained and redundant robots.

Unit 4: Velocity and statics of robot manipulators

Linear and angular velocity of links, Velocity propagation, Manipulator Jacobians for serial manipulators, Singularity analysis for serial manipulators

Unit 5: Dynamics of serial robots :

Mass and inertia of links, Lagrangian formulation for equations of motion for serial manipulators, Generation of symbolic equations of motion using a computer, Simulation (direct and inverse) of dynamic equations of motion, Examples of a planar 2R and four-bar mechanism, Recursive dynamics.

Unit 6: Motion planning and control :

Joint and Cartesian space trajectory planning and generation, Classical control concepts using the example of control of a single link, Independent joint PID control, Control of a multi-link manipulator.

Text Books

1. Mikell P Groover, Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta, “Industrial Robotics, Technology programming and Applications", McGraw Hill, 2012.
2. Craig. J. J. “Introduction to Robotics- mechanics and control”, Addison- Wesley, 1999.

Reference Books

1. S.R. Deb, “Robotics Technology and flexible automation”, Tata McGraw-Hill Education., 2009.
2. Richard D. Klafter, Thomas .A, ChriElewski, Michael Negin, "Robotics Engineering an Integrated Approach", PHI Learning., 2009.
3. Francis N. Nagy, Andras Siegler, "Engineering foundation of Robotics", Prentice Hall Inc., 1987.
4. P.A. Janaki Raman, "Robotics and Image Processing an Introduction", Tata McGraw Hill Publishing company Ltd., 1995.
5. Carl D. Crane and Joseph Duffy, "Kinematic Analysis of Robot manipulators", Cambridge University press, 2008

IV Semester (Minor Specialization)
Department of Mechanical Engineering

Course Code : METM41 **Course : Automotive Engineering**

L: 4 Hrs. T: 0 Hrs. P: 0 Hrs. Per week **Total Credits : 04**

Course Objectives

1. To give insight of the various systems that constitute the modern automobile and the latest trends.
2. To provide an overview of automobile emissions and details of electric vehicle.

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Recognize the fundamentals and applications of various types of automobiles and I.C engines.
2. Identify various fuels for I.C engine, fuel supply system and formation and control of emissions.
3. Illustrate the importance and working of transmission, driveline components including tyres.
4. Explore components and working of steering, braking and suspension system and their importance.
5. Demonstrate the importance and functioning of various electrical, electronic devices and safety systems.
6. Express the need and functional requirements of Electric and hybrid vehicles and latest trends in Automobile.

Syllabus

UNIT I : Introduction and Classification of automobiles, Chassis types and construction, I.C Engines, Lubrication and Cooling. 08 hr

UNIT II : Fuels for I.C Engines, Alternate Fuel, Fuel Supply systems: Carburetor and Fuel Injection system, CRDi. Emissions and its Control. 07hr

Unit III : Transmission and Drive Line Components: Clutches, Gearbox, Driveline Components, Differential. Axles, wheels and Tyres. 08 hr

UNIT IV : Steering, Suspension and Braking system: Need, classification, working, latest trends. 07 hr

UNIT V : Auto Electricals and Electronics, Automotive Lighting, Safety. 08 hr

UNIT VI : Hybrid and Electric vehicles, Auto Mechatronics and latest trends. 07 hr

Text Books

1. Automobile Engineering Vol. 1 & Vol. 2 by Kirpal Singh, Standard Publishers.
2. Automobile Engineering by G.B.S. Narang, Khanna publisher
3. Motor Vehicle Technology -- J.A. Dolan, Heinemann Educational Books

Reference Books

1. Automotive Mechanics -- W.H. Crouse, D.L Anglin, Tata McGraw Hill Education.
2. Motor Vehicle -- K. Newton and W. Seeds, T.K. Gawet, Butterworth, Limited, London, England,
3. Automotive Machanics -- Joseph Heitner, Van Nostrand Reinhold

V Semester (Minor Specialization)
Department of Mechanical Engineering

Course Code : METM51 **Course : Computer Aided Design**

L: 4 Hrs. T: 0 Hrs. P: 0 Hrs. Per week **Total Credits : 04**

Course Objectives

To understand the basic concept of computer graphics to develop welding software and finite element method to analyse the machine element.

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Understand the basic concept of computer aided design and computer graphics.
2. Understand the technique to display of graphical entities like line, circle and ellipse.
3. Apply the knowledge of 2-D transformation to manipulate a geometrical entity.
4. Comprehend the concept of 3-D transformation and various techniques of modeling.
5. Learn the basic concept and applications of FEM to analyze the machine element.
6. Analyze the structure by one dimensional element i.e. 1-D bar and 2-D trusses.

Syllabus

Unit – I: CO1 : Definition of CAD and its application, CAD Softwares modules (Operating System, Graphics, Applications, Programming, Communication). Product life cycle, Various techniques to generate the images, frame buffer, N-bit plane buffers, simple color frame buffer.

Unit – II: CO2 : Rasterization Principle, Rasterization of line, Generation of line, circle and ellipse using Bresenham's and DDA algorithms. Windowing and clipping, Cohen- Sutherland Clipping Algorithm.

Unit-III: CO3 : Two dimensional geometric and co-ordinate transformations like scaling, translation, rotation, reflection, and shear. Concept of homogeneous representation and concatenated transformations. Inverse transformations. (Enumeration of entity on graph paper)

Unit – IV: CO4 : Three dimensional geometric and co-ordinate transformation like scaling, translation, rotation and reflection.

Bezier Curve (for 4 Control points).Introduction to surfaces, surface of revolution. Wire frame modeling, solid modeling of basic entities like box, cone, cylinder. CSG & B-rep technique.

Unit – V: CO5 : Fundamental Concept of Finite Element Method, historical background and applications. Concept of stress analysis, Plain Stress and Strain, Compatibility condition, Minimum potential energy principle. Raleigh-Ritz method, Saint Venant's principle, sky line approach.

Unit – VI: CO6 : Analysis of one dimensional bar and spring element, Displacement function, shape functions for linear & quadratic bar element. Stiffness matrix, Force Matrix. Analysis of two-dimensional trusses.

Text Book

1. Schaum's Outline Series: Theory & Problems of Computer Graphics Roy A. Plastock, Gordon Kalley
2. Introduction to Finite Elements in Engineering: Chandrupatla & A. D. Belegundu (PHI)

Reference Book

1. CAD/CAM, Theory & Practice: Ibrahim Zeid (McGraw Hill)
2. Procedural elements for computer Graphics: D Rogers (McGraw Hill)
3. Mathematical Elements for Computer Graphics Dravid F Rogers, J. Alan Adams (McGraw Hill)
4. Schaum's Outline Series: Theory & Problems of Computer Graphics Roy A. Plastock, Gordon Kalley

VI Semester (Minor Specialization)
Department of Mechanical Engineering

Course Code : METM61 **Course : Automation and Robotics**

L: 4 Hrs. T: 0 Hrs. P: 0 Hrs. Per week **Total Credits : 04**

Course Objectives

To understand the basic concept of automation and robotics to develop automated system.

Course Outcomes

The expected learning outcome is that the students will be able to :

1. Have awareness and understanding of automation knowledge, in terms of production line.
2. Understand various automated material handling systems and logics.
3. Familiarity with CNC technology, thereby achieve multidisciplinary integration.
4. Understand the functional elements of Robotics.
5. Understand the direct and inverse kinematics solution for manipulator.
6. Understand sensors, actuators and application of fixed base and mobile robots.

Syllabus

Unit I:

Fundamental of Automation

Fundamental concepts of Industrial automation and reasons for automating. Types of production and automation, automation strategies, Automated Flow Lines - Methods of workpart transport, Transfer mechanisms, Part feeding devices, Analysis of flow lines with storage buffers, Line balancing methods.

Unit II:

Automated Material Handling

Automated material handling & storage - cob\nveyor systems, Automated Guided Vehicle Systems, Types, Vehicle guidance & Routing, Analysis of AGVS systems, AGVS applications, Automated storage & retrieval system, Carousel storage system.

Unit III:

Computer Numerical Control

Numerical control production systems - NC basic concepts, Machine control unit and other components, DNC and CNC, Types and classifications of CNC systems, CNC part programming. Automated inspection and its types, Coordinate measuring machine, Industry 4.0.

Unit IV:

Introduction to Robotics

Evolution of Robots and Robotics, Law of Robotics, Progressive advancement in robots, Robot Anatomy, Classification of robots, Coordinate frame, mapping and transformation.

Unit V:

Direct and Inverse Kinematics

Mechanical structure and notations, description of link and joints, kinematic modeling if the manipulator, Denavit - Hartenberg notation, manipulator transformation matrix, solvability of inverse kinematic model, solution techniques, direct and inverse kinematic solution by MATLAB or any analytical tools, Introduction to dynamic modeling.

Unit VI:

Robotic sensors, actuators and applications

Path and Trajectory planning, meaning of sensing, various sensors and actuators in robotics, industrial applications of robots i.e. material handling, processing, assembly, inspection, etc. Mobile robots, In - pipe robot for cleaning and inspection, underwater robot, recent in robotic technology.

Text Books

1. Automation, Production System & CIMPS : M. P. Groover, Prentice Hall of India, New Delhi.
2. R. K. Mittal and I. J. Nagrath, " Robotics and Control", McGraw hill Education (India) private limited, 2017.
3. Craig. J. J. " introduction to Robotics - mechanics and control", Addison - Wesley, 1999.

Reference Books

1. B. S. pabla and M. Adithan, " CNC Machines", New Age International, 1994.
2. S. R. Deb, “Robotics Technology and flexible automation”, Tata McGraw-Hill Education., 2009.
3. Richard D. Klafter, Thomas .A, Chri Elewski, Michael Negin, "Robotics Engineering an Integrated Approach", PHI Learning., 2009.
4. Francis N. Nagy, Andras Siegler, "Engineering foundation of Robotics", Prentice Hall Inc., 1987.
5. P. A. Janaki Raman, "Robotics and Image Processing an Introduction", Tata McGraw Hill Publishing company Ltd., 1995.
6. Carl D. Crane and Joseph Duffy, "Kinematic Analysis of Robot manipulators", Cambridge University press, 2008.

VII Semester (Minor Specialization)
Department of Mechanical Engineering

Course Code : METM71 **Course : Solar Energy Technology**

L: 4 Hrs. T: 0 Hrs. P: 0 Hrs. Per week **Total Credits : 04**

Course Objectives

To provide a comprehensive insight of solar energy collection and utilization for thermal and electrical applications.

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Understand the basic terminologies in solar energy technology.
2. Estimate and measure the insolations for given location and time of year.
3. Understand various ways of solar energy utilization.
4. Understand the working of different solar thermal systems.
5. Understand construction and working of different PV systems.
6. Give a preliminary design of typical solar heating and photovoltaic systems.

Syllabus

Energy Scenario and Solar Resources

Global energy scenario, status of solar energy utilization in the world, Introduction to electromagnetic spectrum, solar spectrum, estimation of extraterrestrial radiations, solar constant, air mass, attenuation of solar radiations through atmosphere, solar geometry, measurement of solar radiations, empirical equations for predicting availability of terrestrial radiations

Solar Thermal systems

Principles of solar thermal energy collection, different types of solar thermal collectors, novel designs of collectors, solar energy storage: sensible, latent and thermo chemical storage.

Solar thermal applications

Water and space heating; solar ponds; dryers, distillation, solar cookers, Solar thermal power plants, design of solar thermal systems.

Basics of solar photovoltaics

Photovoltaic effect, different types of photovoltaic cells, cell materials, Module specifications, manufacturing of PV cells and modules, PV cell characteristics, cost of PV technologies.

Components of Photovoltaic Systems

balance of PV systems, module hot spots, bypasses diodes, PV arrays and PV systems, mounting structures, series and parallel connections of PV modules, mismatch in PV connections, charge controllers, MPPT, cables, storage batteries, inverters.

Design of PV Systems

Standalone PV systems, grid connected PV systems

Text Books :

1. Solar Energy: Principles of Thermal Collection and Storage, S.P. Sukhatme, 2nd edition, Tata McGraw Hill New Delhi, 1984.
2. Solar Photovoltaics: Fundamental Applications and Technologies, C. S. Solanki, 2nd edition, Prentice Hall of India New Delhi 2011.

Reference Books

1. Solar Engineering of Thermal Processes, Duffie. J. A. & W. A. Beckman, 3rd edition, John Wiley & Sons, 2006.
2. Renewable Energy Resources, John Twidell, Tony Weir, Taylor & Francis; 2nd edition, 2005
3. Solar Energy Fundamentals and applications, H.P,Garg, J Prakash,1st edition, Tata Mc Graw Hill, New Delhi, 1997.

VIII Semester (Minor Specialization)
Department of Mechanical Engineering

Course Code : METM81-1 **Course : Manufacturing Engineering**

L: 4 Hrs. T: 1 Hrs. P: 0 Hrs. Per week **Total Credits : 04**

Course Objectives

To prepare students to equipment and understand the various processes required for product manufacturing.

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Select a suitable manufacturing process for desired components.
2. Select a suitable engineering material for a product to manufacture.
3. Select a suitable casting/forming method to manufacture metal components.
4. Select suitable joining processes for fabrication work of ferrous and non ferrous metals.
5. Identify the machine tool, cutting tool materials and cutting fluids for different machining operations.
6. Select an appropriate NTM and advanced machining process for manufacturing complex shape component.

Syllabus

Unit - I

Introduction, Classification of manufacturing processes, kinds of production, computers in manufacturing, selection of manufacturing process.(3)

Unit-II

Engineering materials and their properties, importance of heat treatment. (5)

Unit-III

Primary manufacturing processes. Introduction to casting, forming ,Rolling ,forging, extrusion and sheet metal working processes, processing of plastics.(8)

Unit-IV

Fabrication processes, classification of welding processes, Soldering, brazing and advanced welding processes. (6)

Unit-V

Metal cutting, Single and multi-point cutting tools, Cutting tool materials, Tool life, Cutting fluids, Types of machine tools, Turning, Drilling, Milling and finishing processes, (8)

Unit-VI

Unconventional and Advanced Machining Processes:

Abrasive Jet Machining, Electrical Discharge Machining, Electro-chemical machining (ECM), Laser Beam Machining (LBM), Electron Beam Machining

Introduction to CNC, FMS, GT and CIMS. (10)

Text Books

1. Manufacturing Technology (Vol I and II) – P.N. Rao, Tata McGraw Hill Pub. Company, New Delhi.
2. Kalpakjian and Schmid, Manufacturing processes for engineering materials (5th Edition)-Pearson India, 2014
3. Production Engineering –P.C. Sharma, S. Chand and Company Ltd., New Delhi.

Reference Books

1. Manufacturing Science – A. Ghosh & A.K. Mallik – East West Press Pvt. Ltd., New Delhi.
2. Workshop Technology (Volume-I & II) - By Hajra Choudhary, Media Promoters & Publishers Pvt. Ltd.
3. Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems.

VIII Semester (Minor Specialization)
Department of Mechanical Engineering

Course Code : METM81-2 **Course : Mechanical Engineering Design**

L: 4 Hrs. T: 1 Hrs. P: 0 Hrs. Per week **Total Credits : 04**

Course Objectives

1. To illustrate to students the variety of mechanical components.
2. To teach students how to apply mechanical engineering design theory to identify machine elements in the design of commonly used mechanical systems.

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Understand the basic concepts of Engineering Design.
2. Design of various types of joints.
3. Design the Helical springs and power screw.
4. Design of shafts.
5. Design the mechanical drives like belt drive and gear drive.
6. Design & selection of bearings.

Syllabus

Unit 1 [10 hours] Fundamentals of Mechanical Engineering Design

Mechanical engineering design, Phases of design process, Design considerations, Engineering Materials and their Mechanical properties, Standards and Codes, Factor of safety, Material selection. Static Stresses: Static loads - Normal, Bending, Shear and Combined stresses. Stress concentration and determination of stress concentration factor.

Unit 2 [08 hours]

Temporary And Permanent Joints : Threaded fasteners – Bolted joints including eccentric loading, Knuckle joints, Cotter joints – Welded joints, riveted joints for structures – theory of bonded joints.

Unit 3 [08 hours]

Mechanical Springs: Compression and tension helical springs, Design of helical springs subjected to static and fatigue loading.

Power Screws: Forms of threads, multiple threads, Efficiency of square threads,

Trapezoidal threads, Stresses in screws, Design of screw jack.

Unit 4 [08 hours]

Design of Shafts: Materials for shaft, Stresses in shafts, Design of solid and hollow circular shaft subjected to torque and combined loading; Design of shaft for rigidity and stiffness.

Unit 5 [08 hours] Design of Mechanical Drives

Power transmission and drives, Belt Drives: design of v-belt drives, Gear drives, Design of spur gears.

Unit 6 [08 hours]

Rolling Contact bearing: types, static and dynamic load carrying capacity, selection of rolling contact bearings.

Sliding contact bearings: Basic Modes of lubrication, Hydrostatic and hydrodynamic bearing, design parameters. Comparison of Rolling and Sliding contact bearings.

Text Books

1. Bhandari, V. B. Design of machine elements. Tata McGraw-Hill Education, 2010.

Reference Books

1. Shigley, Joseph Edward. Shigley's mechanical engineering design. Tata McGraw-Hill Education, 2011.

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