Kolhapur Institute of Technology's College of Engineering (Autonomous), Kolhapur

Curriculum (Structure)

For

(Mechanical Engineering Design)

(Post Graduate Programme)

From Academic Year 2021-22

Kolhapur Institute of Technology's College of Engineering, Kolhapur

Teaching and Evaluation scheme for
First Year M. Tech. Program in (Mechanical Engineering Design) Semester-I

Course Code	Course Name	Hr/Week			Credits		Evaluation Scheme			
							Component	Marks		
		L	T	P				Max	Min for Passing	
PMDN0101	Noise , Vibration and Harshness	3	-	-	3		ISE-I	10	20	40
							MSE	30		
							ISE-II	10		
							ESE	50	20	
PMDN0102	Theory of Elasticity	3	1	-	4		ISE-I	10	20	40
							MSE	30		
							ISE-II	10		
							ESE	50	20	
PMDN0103	Research Methodology and Design of Experiments	3	1	-	4		ISE-I	10	20	40
							MSE	30		
							ISE-II	10		
							ESE	50	20	
PMDN0161	Numerical Methods *	2	-	-	-		ESE	50	20	
PMDN01**	Professional Elective-I	3	1	-	4		ISE-I	10	20	40
							MSE	30		
							ISE-II	10		
							ESE	50	20	
PMDN01**	Professional Elective-II	3	-	-	3		ISE-I	10	20	40
							MSE	30		
							ISE-II	10		
							ESE	50	20	
PMDN0131	Noise, Vibration and Harshness Lab	-	-	2	1		ISE	50	20	
							ESE (P.O.E.)	50	20	
PMDN0132	Elective II Lab	-	-	2	1		ISE	50	20	
PMDN0133	Object Orientated Programming Lab	-	-	2	1		ISE	50	20	
							ESE (P.O.E.)	50	20	
PMDN0134	Research Lab.	-	-	2	1		ISE	50	20	
PMDN0141	Seminar I			2	1		ESE	100	40	
	Total	15 +2	3	10	23		Total Credit: 23 Total Contact Hours/Week: 28+2 hrs			

*Audit Course

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List of Professional Electives:

Course Code	Elective – I	Course Code	Elective – II
PMDN0121	Design For Manufacturing, Assembly and Reliability	PMDN0126	Industrial Fluid Power and Automation
PMDN0122	Vehicle Dynamics	PMDN0127	Product Design Development
PMDN0123	Tribology in Design	PMDN0128	Mechatronics System Design
PMDN0124	Engineering fracture Mechanics	PMDN0129	Rapid Prototyping
PMDN0125	Experimental Stress Analysis	PMDN0130	Design of Thermal Systems

ISE: In Semester Evaluation
MSE: Mid Semester Examination
ESE: End Semester Examination

Elective – II Laboratory

Course Code	Elective – II
PMDN0136	Industrial Fluid Power and Automation Lab
PMDN0137	Product Design Development Lab
PMDN0138	Mechatronics System Design Lab
PMDN0139	Rapid Prototyping Lab
PMDN0140	Design of Thermal Systems Lab

Kolhapur Institute of Technology' College of Engineering, Kolhapur

Teaching and Evaluation scheme for

First Year M. Tech. Program in (Mechanical Engineering Design) Semester-II

Course Code	Course Name	Hr/Week			Credits		Evaluation Scheme			
							Component	Marks		
		L	T	P				Max	Min for Passing	
PMDN0204	Advanced Finite Element Methods	3	-	-	3		ISE-I	10	20	40
							MSE	30		
							ISE-II	10		
							ESE	50	20	
PMDN0205	Analysis and Synthesis of Mechanisms	3	1	-	4		ISE-I	10	20	40
							MSE	30		
							ISE-II	10		
							ESE	50	20	
PMDN0206	Advanced Materials	3	1	-	4		ISE-I	10	20	40
							MSE	30		
							ISE-II	10		
							ESE	50	20	
PMDN0262	Industry 4.0*	2	-	-	-		ESE	50	20	
PMDN02**	Professional Elective III	3	1	-	4		ISE-I	10	20	40
							MSE	30		
							ISE-II	10		
							ESE	50	20	
PMDN02**	Professional Elective IV	3	1	-	4		ISE-I	10	20	40
							MSE	30		
							ISE-II	10		
							ESE	50	20	
PMDN0237	Finite Element Analysis Lab	-	-	2	1		ISE	50	20	
							ESE (O.E.)	50	20	
PMDN0238	Conditional Monitoring and Fault Diagnosis Lab	-	-	2	1		ISE	50	20	
PMDN0239	Design Engg Lab	-	-	2	1		ISE	50	20	
PMDN0240	Computer Aided Design Lab	-	-	2	1		ISE	50	20	
PMDN0241	Mini-Project	-	-	2	1		ESE	100	40	
PMDN0242	Pre Dissertation Seminar	-	-	2	1		ISE	50	20	
	Total	15 +2	4	12	25		Total Credit: 25 Total Contact Hours/Week: 31+2 hrs			

*Audit course

Kolhapur Institute of Technology's College of Engineering, Kolhapur

List of Professional Electives:

Course Code	Elective – III	Course Code	Elective – IV
PMDN0221	Process Equipment Design	PMDN0226	Advanced Machine Tool Design
PMDN0222	Design of Material Handling Equipment	PMDN0227	Computational Fluid Dynamics
PMDN0223	Optimization Techniques in Mechanical Engineering	PMDN0228	Industrial Automation & Robotics
PMDN0224	Micro & Nano System Design	PMDN0229	Aesthetic & Ergonomic Design
PMDN0225	Design for Fatigue	PMDN0230	Cost Management of Engineering Projects
		PMDN0231	Conditional Monitoring and Fault Diagnosis

ISE: In Semester Evaluation
MSE: Mid Semester Examination
ESE: End Semester Examination

Kolhapur Institute of Technology' College of Engineering, Kolhapur

Teaching and Evaluation scheme for

Second Year M. Tech. Program in (Mechanical Engineering Design) Semester-I

Course Code	Course Name	Hr/Week			Credits		Evaluation Scheme		
		L	T	P			Component	Marks	
								Max	Min for Passing
PMDN0343	Industrial Training*	-	-	-	2		ISE	50	20
PMDN0351	Dissertation Phase-I	-	-	-	2		ISE-I	50	20
					4		ISE-II	100	40
					4		ESE(OE)	100	40
Total Credits					**12**		**Total Marks**	**300**	
Contact Hours/week : 5/Student/week									

*Student should undergo industrial training of 15days during vacation after F.Y.Part II

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Teaching and Evaluation scheme for

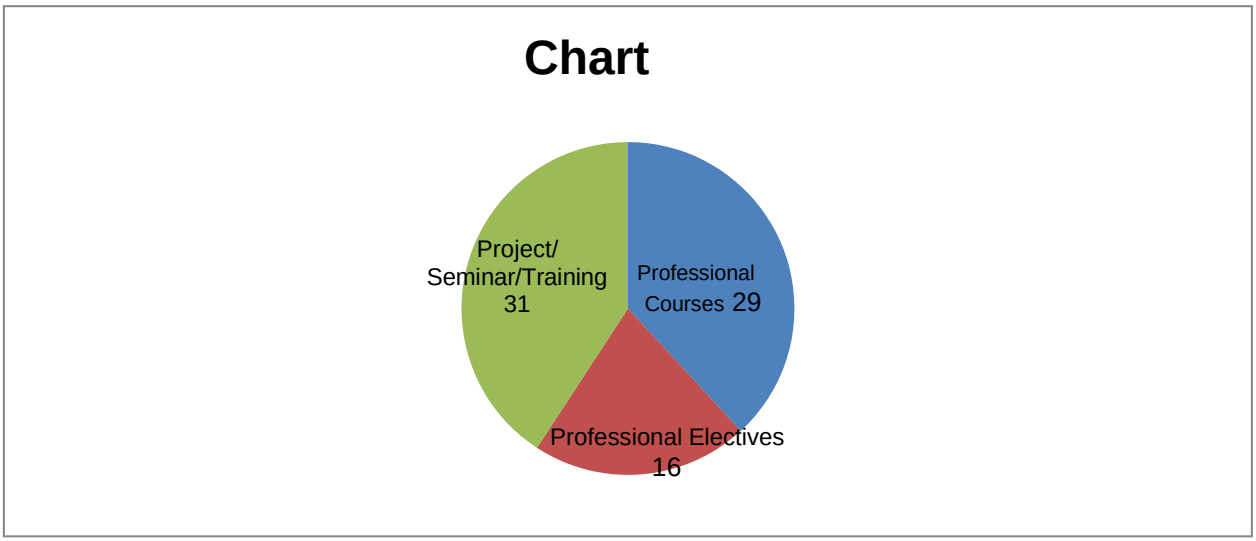
Second Year M. Tech. Program in (Mechanical Engineering Design) Semester-II

Course Code	Course Name	Hr/Week			Credits		Evaluation Scheme		
		L	T	P			Component	Marks	
								Max	Min for Passing
PMDN0453	Dissertation Phase- II	-	-	-	4		ISE-I	100	40
		-	-	-	4		ISE-II	100	40
		-	-	-	8		ESE	200	80
Total Credits					**16**		**Total Marks**	**400**	
Total Contact Hours: 5/student/week									

Kolhapur Institute of Technology' College of Engineering, Kolhapur

Program Credit Distribution

Sr No	Curriculum Component	Credits
1	Professional Courses	29
2	Professional Electives	16
3	Project/Seminar/Training/Internship	31
	Total	**76**

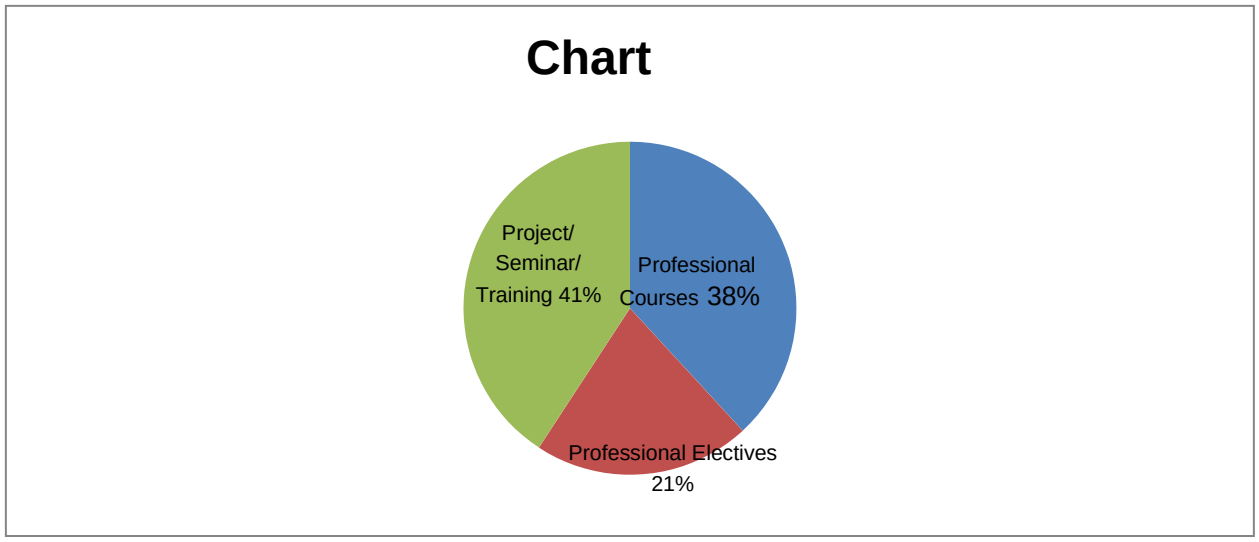


(Mechanical Engineering Design) (PG)

Kolhapur Institute of Technology' College of Engineering, Kolhapur

Program Credit Distribution Percent wise

Sr No	Curriculum Component	Percentage
1	Professional Courses	38
2	Professional Electives	21
3	Project/Seminar/Training/Internship	41
	Total	**100**



(Mechanical Engineering Design) (PG)

Title of the Course: NOISE,VIBRATIONS AND HARSHNESS Course Code: PMDN0101	L	T	P	Credit
	03	-	-	03

Course Pre-Requisite: Basics of Dynamics of Machines

Course Description: Many practical applications need investigation of Vibration such as design of machines, engines, turbines, structures, etc. Study of vibration is necessary to improve performance of system and to optimize the system. The subject contains - Free and forced vibrations of one-degree-of-freedom systems with and without viscous damping. Introduction to torsional vibration. Two degree of freedom systems, Multi degree vibrations. Numerical methods for multi degree vibration analysis. Introduction to Acoustics and Noise effects and measurement.

Course Objectives:

1. Overview of basic concepts of vibration analysis.
2. Study vibration analysis of multidgree of freedom systems
3. Acquaint with the principles of vibration measuring instruments.
4. Acquaint with Acoustic parameters and noise measurement.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Explain fundamentals of noise and vibration in mechanical systems.	II	Understanding
CO2	Solve numerical of natural frequency of mechanical system.	III	Applying
CO3	Analyze vibratory response of mechanical system.	IV	Analyze
CO4	Estimate the parameters of Noise and Vibratory System.	V	Evaluate
CO5	Develop mathematical model to represent dynamic system.	V	Design

CO-PO Mapping:

	PO1	PO2	PO3
CO1	1		1
CO2	2	1	
CO3	2	1	1
CO4	2	1	
CO5	3	2	1

1:low, 2: medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:- Two Degrees of Freedom: a) Overview of analysis of Single Degree of Freedom systems (Free, forced, damped and undamped vibration) b) Free un damped vibrations – Principal modes and natural frequencies, Co-ordinate coupling and principal co-ordinates. c) Forced vibrations (Un damped) – Harmonic excitation, Vibration Dampers and absorbers, Dynamic vibration absorber – Tuned and Un tuned type, Two rotor system	08 **Hrs.**
Unit 2:- Introduction to Multi degrees of Freedom : Free vibrations of Multi DOF System-Flexibility and stiffness influence coefficient, Equation of motion , Rayleigh's method, Matrix Method, Matrix iteration method .	08 **Hrs.**
Unit 3: Non-Linear Vibrations: Introduction, Sources of nonlinearity, Qualitative analysis of nonlinear systems **Random Vibrations:** Random phenomena, Time averaging and expected value, Frequency response function	08 **Hrs**
Unit 4:- Vibration Measurement and Applications - Instruments for measurement of displacement, velocity, acceleration and frequency of vibration, Sensors and Actuators, signal conditioners, Time and frequency domain plot, Spectral analyzers, Exciters, FFT analyzer, Condition Monitoring and Fault Diagnosis.	06**Hrs.**
Unit 5 – Basics of Noise : **a)** Basic definitions, human response to sound, Decibel scale, Relation among sound power, Sound intensity and sound pressure level, Octave Band Analysis, Noise- Effects, Rating and regulation Non auditory and Auditory effects of noise, Noise standards and limits, Ambient emission noise standards in INDIA, Hazardous noise explosion, Day night noise level.	05**Hrs.**
Unit 6 – Noise Measurement and control : Noise sources and control, Automotive noise control principles, Sound in enclosures, Sound energy absorption, Sound transmission through barriers, Noise measuring systems and instruments, psychoacoustic effects of sound.	05**Hrs.**

Textbooks:

1. "Mechanical Vibrations", Singiresu S.Rao , Pearson Education, ISBM –81-297-0179-0 -

(2004).
2. “Mechanical Vibrations”, G. K. Grover, Published by Nemchand and Brothers, Roorkee.
3. “Mechanical Vibrations”, Dr. V. P. Singh, Published by S. Chand and Sons New Delhi.
4. “Noise and Vibration Control”, Leo L. Bernack, Tata Mc- Graw Hill Publication.
5. “Mechanical Vibration and Noise Engineering”,A. G. Ambekar, Prentice Hall of India.
6. “Fundamentals of Vibrations”, Balchandran Magrab ,Cengage Learning.
7. “Theory of Vibrations with Applications”, W. Thomson, Pearson Education,2nd Edition.
8. “Mechanical Vibration”,Dr Debabrata Nag, Wiley India Pvt. Ltd ,ISBN 978-81-265-3090-

References:

1. “Mechanical Vibration”,Austin Church, Wiely Eastern. 2nd Edition.
2. “Schaumm’s Outline series in Mechanical Vibration”, S. Graham Kelly, 6th Edition.
3. “Kinematics, Dynamics and Design of Machinery”,Waldron, Willey India, 2nd Edition.
4. “Mechanical Vibrations”, J.P. Den Hartog, Tata McGrawhill Book Company Inc., 4th Edition.
5. “Introduction to Dynamics and Control”, Leonard Meirovitch, J. Wiley, New York.
6. “Elements of Vibration Analysis” Leonard Meirovitch, Tata McGrmv-Hill, New York. 2nd Edition.
7. “Principles of Vibration”,Benson H. Tongue,Oxford University Press., 4th Edition.
8. “Vibrations and Noise for Engineers”, Kewal Pujara Dhanpat Rai and Sons, (1992).
9. “Mechanical vibration”, William J Palm III Wiley India Pvt. Ltd., ISBN 978-81-265-3168-4, 1st Edition.
10. “Fundamentals of vibrations”, Leonard Meirovitch, McGraw Hill International Edition.
11 “Principles of Vibration Control”, . Asok Kumar Mallik, Affiliated East-West Press.
12 “Mechanical Vibrations”, A.H. Church, John Wiley and Sons, Inc, New York, 1994.

Unit wise Measurable students Learning Outcomes:

1. **Identify types of vibratory system as Undamped, Damped, SDOF, MDOF**
2. **Model the vibratory system for analysis purpose.**
3. **Evaluate natural frequencies and mode shapes of SDOF systems.**
4. **Evaluate natural frequencies and mode shapes of MDOF systems.**
5. **Measure the vibration parameters of system using instruments.**
6. **Understand the terms related to acoustic and measure the noise level.**

Title of the Course: Theory of Elasticity	L	T	P	Credit
Course Code: PMDN0102	3	1	-	4

Course Pre-Requisite: Acquaintance with the basic concepts of Mechanics of Materials, strength of materials and Machine Design.

Course Description:

Course Description:

This course is designed to develop student's ability in advanced stress analysis and its applications in linear and non-linear mechanics. After the completion of course, students will have analytical skills to solve practical problems in their professional career. The course contents are important for design of various components and also for finite element analysis problems. The course includes analysis of stress, analysis of strain, two dimensional problems, axi-symetric problems, torsion problems, energy methods and contact stresses.

Course Objectives:

1. To understand the fundamentals of elasticity in comparison with the mechanics of deformable bodies.
2. To develop systematic knowledge of basic concepts like stress, strain, equilibrium, compatibility and failure theories, relate the stresses and strains in terms of elastic constants and understand the importance of these constants.

3. To understand the fundamental concepts of stress analysis in two dimensions using stress functions.

4. To compute the solution for engineering problems using the concept of strain energy related equations.

5. To learn analysis of contact stresses and the related design methodology.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	**Apply** the basic concepts of elasticity and plasticity while understanding the limitations of the 'Mechanics of Materials' to solve practical problems.	III	Applying
CO2	**Select** the correct analytical techniques to : (i) Determine internal forces, stresses and strains (ii) Predict failure of simple components. and to prepare document	III	Applying
CO3	**Calculate** displacements, stresses etc for simple beam problems (cantilever, simply supported) using stress functions.	V	Evaluating
CO4	**Select** the energy methods and obtain solutions to elastic bodies subjected to various loads.	III	Applying

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	3	1	1
CO2	2	3	1
CO3	2	2	1
CO4	2	2	2

1:low, 2: medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:--- Analysis of Stress Basic concepts: Body force, Surface Force, Stresses, Components of Stresses, State of stress at a point, Stress components on an arbitrary plane, Principal stresses, Shear stresses, Stress transformation, Mohr's circle in 3D, Plane stress, Differential equations of equilibrium, Boundary conditions, Stress invariants, Octahedral stresses, Decomposition of a state of stress.	8-**Hrs.**
Unit 2:--- Analysis of Strain Deformation, Strain displacement relations, Strain components, State of strain at a point, Dilatation, Compatibility conditions, Plane strain	4 -**Hrs.**
Unit 3:--- Stress- Strain relations Generalized Hooke's Law in terms of elastic constants, Relations between elastic constants, Displacement equations of equilibrium, Saint Venant's principle	4 -**Hrs.**
Unit 4(A):--- Two dimensional problems in Cartesian co-ordinates Airy's stress function, Biharmonic equilibrium equations, Investigation for simple beam problems: (a) Bending of a cantilever beam with end load. (b) Simply supported beam with uniform load.	6 -**Hrs.**
Unit 4(B):--- Analysis of axi-symmetric problems and Torsion **Axi-symmetric problems:** General equations in polar co-ordinates, Thick-walled cylinder subjected to external and internal pressure, Rotating disc as a 2D problem,	6- **Hrs.**

Shrink fits **Torsion:** Torsion of prismatic (circular and elliptical cross-section) bars, Soap film analogy, Membrane analogy	
Unit 5 :--- Energy Methods Concept of elastic strain energy, Strain energy due to axial force, shear force, torsion, bending moment, Principle of superposition, Maxwell-Betti-Rayleigh reciprocal theorem, Castigliano's theorems, Principle of virtual work.	6 -**Hrs.**
Unit 6 :--- Contact Stresses – Geometry of contact surfaces, Analysis of contact stresses and deflection of bodies having point contact, stress analysis of bodies having line contact, analysis of low speed impact.	6 -**Hrs.**

Textbooks:

1. S. P. Timoshenko and J N Goodier, "**Theory of Elasticity**", McGraw Hill Book Company.
2. L. S. Srinath, "**Advanced Mechanics of Solids**", Tata McGraw Hill Book Company .
3. Richard G Budynas, "**Advanced Strength and Applied Stress Analysis",** McGraw Hill , New Delhi, Second Edition, 2011.
4. A.P.Boresi and K.P. Chang,"Elasticity in Engineering Mechanics", John Willey and Sons, Second Edition, 2014.

References:

1] Sadhusingh, "**Theory of Elasticity**", Khanna Publishers, New Delhi, Fourth Edition, 2012.
2] Wang C. T. , "**Applied Elasticity**", McGraw Hill, New Delhi, 1990.
L. D. Landau and E. M. Lifshitz, "**Theory of Elasticity",** Vikas Publishing House Private. Ltd, New Delhi.
3] T. G. Sitharam, "**Applied Elasticity**", Interline Publishing.
4] Phillips, Durelli and Tsao, "**Analysis of Stress and Strain"** McGraw Hill Book Company.
5] Introduction to the Theory of Plasticity for Engineers- Haffman and Sachs, LLC, 2012.
6] Theory of plasticity - J Chakrabarty, Butterworth, 2006.
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Unit wise Measurable students Learning Outcomes:

1. The student shall be able to calculate the stresses generated in bodies owing to the presence of various forces.

2. The student shall be able to calculate the strains / displacements in bodies due to the presence of various forces.

3. The student shall be able to establish relations between the elastic constants using the appropriate constitutive relations

4a. The student shall be able to calculate displacements and stresses in simple beam problems.

4b. The student shall be able to apply the principles of axi-symmetry and soap film analogy to problems involving pressure vessels (thick and thin walled) and bars subjected to torsion.

5. The student shall be able to calculate the strains / displacements/forces using the

energy methods.
6. The student shall be able to analyze contact stresses between bodies having point and line contact.

Title of the Course: Research Methodology for Mechanical Design Engineers Course Code: PMDN0103	L	T	P	Credit
	3	1	-	4

Course Objectives:

1. To understand the basics of research.
2. To acquire knowledge of research design.
3. To acquire knowledge of research modeling.
4. To study and use the experimentation and factorial design.
5. To study and interpret the analysis in research.

Course Learning Outcomes:

	CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor	
	CO1	Familiarize with research and types of research.	1	Understand	
	CO2	Know various steps in the research methodology.	2	Describe	
	CO3	Prepare the proposal for the research investigation	2	Know	
	CO4	Understand and interpret, using statistical tools, experimental data and characteristic behavior	3	Apply	

CO-PO Mapping :

CO	PO 1	PO 2	PO 3
CO1	2		1
CO2	2		1
CO3	1	2	1
CO4		2	1

1:low, 2:medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

	Assessment	Marks	
	ISE 1	10	
	MSE	30	
	ISE 2	10	
	ESE	50	

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc. MSE: Assessment is based on 50% of course content (Normally first three modules) ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.	
Course Contents:	
Unit 1:- Introduction: Defining Research, Scientific Enquiry, Hypothesis, Scientific Method, Types of Research, Research Process and steps in it. Research Proposals -Types, contents,sponsoring agent's requirements, Ethical, Training, Cooperation and Legal aspects, Research problem selection, Necessity of defining the problem.	**Hrs.**
Unit 2:- Research Design: Meaning, Need, Concepts related to it, categories; Literature Survey and Review, Dimensions and issues of Research Design, Research Design Process - Selection of type of research, Measurement and measurement techniques ,Selection of Sample, Selection of Data Collection Procedures, Selection of Methods of Analysis, Errors in Research.	**Hrs.**
Unit 3:- Research Modelling: (a) Mathematical - Classification of Models, Development of Models, Stages in Model building, Principles of Modelling, Use of Analogy, Models as Approximations, Data consideration and Testing of Models (b) Heuristics and Simulation - Definition, Applications and reasons for using Heuristics, Heuristic Methods and approaches, Meta-Heuristics; Simulation - Meaning, Applications and Classification of Simulation Models, Process of Simulation, Steps and Features of Simulation Experiments and their Validation.	**Hrs.**
Unit 4:- **Introduction to DOE:** Approaches to the study of the research problem and problem formulation, formulation of hypotheses, feasibility, preparation and presentation of proposal for a research investigation, basic principles of design of experiments, some typical applications of experimental design, guidelines for designing experiments, strategy of experimentation	**7 Hrs.**
Unit 5:- **Introduction to Statistical Analysis:** Probability and probability distributions; binomial, Poisson, exponential and normal distributions and their applications, primary and secondary data, their collection and validation, methods of sampling, regression and correlation analysis, linear regression models, estimate of parameters in linear regression models.	**7 Hrs.**

Unit 6:- **Analysis of Variance:** Introduction, regression model diagnostics, hypothesis testing in multiple regression, confidence intervals in multiple regression, testing for lack of fit, tests of significance based on normal, t and chi-square distributions, the F-test, example of ANOVA process, degrees of freedom, error variance and pooling, error variance and application **Report Writing:** Pre-writing Considerations, Principles of Thesis Writing, Formats of Report Writing & Publication in Research Journals, Oral Presentations (Briefing)	**7 Hrs.**

Textbooks:

- Douglas C Montgomery, 'Design and Analysis of Experiments', John Wiley & Sons, New York, 1996, 4th Edition .
- John P.W.M., 'Statistical Design and Analysis of Experiments', Macmillan, New York, 1971
- Montgomery D.C., Runger G. C., 'Introduction to Linear Regression Analysis', Wiley New York, 1992, 2nd Edition

References:

1] Myers R.H., Montgomery D. C., 'Response Surface Methodology: Process And Product Optimisation Using Designed Experiments', Wiley, New York, 1995

2] Taguchi, 'Introduction to Quality Engineering', Asian Productivity Organisation, G. UNIPUB, White Plains, New York

Unit wise Measurable students Learning Outcomes:

- **The student shall be able to understand the concept Research and its feasibility.**
- **The student shall be able to understand Statistical analysis.**
- **The student shall be able to understand the concept of Regression analysis**

Title of the Course: NOISE,VIBRATIONS AND HARSHNESS LAB Course Code: PMDN0131	L	T	P	Credit
	-	-	02	01

Course Pre-Requisite: Basics of Dynamics of Machines

Course Description: Many practical applications need investigation of Vibration such as design of machines, engines, turbines, structures, etc. Study of vibration is necessary to improve performance of system and to optimize the system. The subject contains - Free and forced vibrations of one-degree-of-freedom systems with and without viscous damping. Introduction to torsional vibration. Two degree of freedom systems, Multi degree vibrations. Numerical methods for multi degree vibration analysis. Introduction to Acoustics and Noise effects and measurement.

Course Objectives:

1. Overview of basic concepts of vibration analysis.
2. Study vibration analysis of multi degree of freedom systems
3. Acquaint with the principles of vibration measuring instruments.
4. Acquaint with Acoustic parameters and noise measurement.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Explain fundamentals of noise and vibration in mechanical systems.	II	Understanding
CO2	Solve numerical of natural frequency of mechanical system.	III	Applying
CO3	Analyze vibratory response of mechanical system.	IV	Analyze
CO4	Estimate the parameters of Noise and Vibratory System.	V	Evaluate
CO5	Develop mathematical model to represent dynamic system.	V	Design

CO-PO Mapping:

	PO1	PO2	PO3
CO1	1		1
CO2	2	1	
CO3	2	1	1
CO4	2	1	
CO5	3	2	1

1:low, 2:medium, 3:high

Assessments :

Teacher Assessment:

One component of In Semester Evaluation (ISE) and one component of End Semester Examination (ESE) having 50% weightage each.

Assessment	Marks
ISE 1	25
ESE (OE)	25

ISE is based on performance of experiments and timely submission of journal, internal oral.
ESE: Assessment is based oral/practical exam.

Course Contents:

Experiment No. 1:- Experiment on Equivalent spring mass system.	02**Hrs.**
Experiment No. 2: - Experiment on torsional vibration of two rotor without damping	
Experiment No. 3:--- Experiment on free vibration of a coupled pendulum and/or double pendulum	02 **Hrs.**
Experiment No. 4:--- Use of different types of exciters for vibration analysis.	02 **Hrs.**
Experiment No. 5:--- Measurement of vibration parameters using vibration measuring instrument.	02**Hrs.**
Experiment No. 6:--- Assignment on MDOF systems. (minimum Six Problems covering all methods)	02**Hrs.**
Experiment No7:--- Introduction to FFT Analyzer	02**Hrs.**
Experiment No. 8: --- Measurement of Noise by Noise measuring instrument	02**Hrs.**
Experiment No. 9: -- Case Studies of Condition Monitoring (Minimum Two)	02**Hrs.**
Experiment No. 10: Vibration analysis using MATLAB/CAE (Minimum 4 problems)	02**Hrs.**

Textbooks:

1. "Mechanical Vibrations", Singiresu S.Rao , Pearson Education, ISBM –81-297-0179-0 - (2004).
2. "Mechanical Vibrations", G. K. Grover, Published by Nemchand and Brothers, Roorkee.
3. "Mechanical Vibrations", Dr. V. P. Singh, Published by S. Chand and Sons New Delhi.
4. "Noise and Vibration Control", Leo L. Bernack, Tata Mc- Graw Hill Publication.
5. "Mechanical Vibration and Noise Engineering",A. G. Ambekar, Prentice Hall of India.
6. "Fundamentals of Vibrations", Balchandran Magrab ,Cengage Learning.
7. "Theory of Vibrations with Applications", W. Thomson, Pearson Education,2nd Edition.
8. "Mechanical Vibration",Dr Debabrata Nag, Wiley India Pvt. Ltd ,ISBN 978-81-265-3090-8.

References:

1. "Mechanical Vibration",Austin Church, Wiely Eastern. 2nd Edition.
2. "Schaumm's Outline series in Mechanical Vibration", S. Graham Kelly, 6th Edition.
3. "Kinematics, Dynamics and Design of Machinery",Waldron, Willey India, 2nd Edition.
4. "Mechanical Vibrations", J.P. Den Hartog, Tata McGrawhill Book Company Inc., 4th Edition.
5. "Introduction to Dynamics and Control", Leonard Meirovitch, J. Wiley, New York.
6. "Elements of Vibration Analysis" Leonard Meirovitch, Tata McGrmv-Hill, New York. 2nd Edition.
7. "Principles of Vibration",Benson H. Tongue,Oxford University Press., 4th Edition.
8. "Vibrations and Noise for Engineers", Kewal Pujara Dhanpat Rai and Sons, (1992).
9. "Mechanical vibration", William J Palm III Wiley India Pvt. Ltd., ISBN 978-81-265-3168-4, 1st Edition.
10. "Fundamentals of vibrations", Leonard Meirovitch, McGraw Hill International Edition.

11 “Principles of Vibration Control”, . Asok Kumar Mallik, Affiliated East-West Press.
12 “Mechanical Vibrations”, A.H. Church, John Wiley and Sons, Inc, New York, 1994.

Unit wise Measurable students Learning Outcomes:

1. **Identify types of vibratory system as Undamped, Damped, SDOF, MDOF**
2. **Model the vibratory system for analysis purpose.**
3. **Evaluate natural frequencies and mode shapes of SDOF systems.**
4. **Evaluate natural frequencies and mode shapes of MDOF systems.**
5. **Measure the vibration parameters of system using instruments.**
6. **Understand the terms related to acoustic and measure the noise level.**

Title of the Course: Numerical Methods	L	T	P	Credit
Course Code: PMDN0161	2	-	-	0

Course Pre-Requisite:

Engineering Mathematics-I, Engineering Mathematics-II, Engineering Mathematics-III, Numerical Methods in Engineering

Course Description:

The course is aimed to provide elementary knowledge of numerical methods and statistical techniques and enable students to apply various tools and techniques to solve problems in mechanical engineering. The subject provides the students with a strong background on numerical approximation strategies and a basic knowledge on the theory that supports numerical algorithms. The course starts with introduction of numerical methods and its applicability in mechanical engineering with an introduction to basic computation using C++ or MATLAB. It covers the concepts of solution techniques of linear and non-linear equations and systems of equations. Differentiation and integration using numerical methods are covered. Application of different initial value and boundary value problems in mechanical engineering using finite difference method is taught. An introduction to solution of partial differential equation and finite element method is also covered.

Course Objectives:

1. To provide the student with general techniques to formulate, model and mathematically solve advanced design engineering problems.
2. To introduce the students with basic numerical methods and software tools for solving design engineering problems.
3. To enable the students to use appropriate analytical and computational tools to investigate design problems.
4. To prepare students to outline the physical systems and formulate mathematical models for them.
5. To make students to solve differential equations using numerical techniques and transform technique.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		level	Descriptor
CO1	Solve design engineering problems by using appropriate numerical methods	II	Understanding
CO2	Conduct experiments and analyze the numerical data.	II	Understanding
CO3	Interpret interpolation, statistical data and approximation for design engineering problems.	II	Understanding
CO4	Design machines, systems and projects required for industry.	III	Applying
CO5	Formulation of the mathematical models of design engineering problems	III	Applying

CO-PO Mapping:

	PO1	PO2	PO3
CO1	**1**		
CO2	**1**		
CO3	**1**	**2**	
CO4	**1**	**2**	**2**
CO5	**1**	**2**	**3**

1:low, 2:medium, 3:high

Assessments :

Teacher Assessment:

End Semester Examination (ESE) for 100 marks

Assessment	Marks
ESE	100

Course Contents:

Unit 1:--- **Errors:** Introduction of Numerical error and accuracy, Types of errors, Rules for estimate errors, Error Analysis, accuracy of numerical results. **Roots of Equation** Bisection method, Regula falsi method Newton Raphson's, Multiple Roots, Iteration system of non- linear Equations, Secant method. Roots of polynomial: Muller's Method	**7 Hrs.**
Unit 2:--- Linear Algebraic Equation: Gauss Elimination Method- Naïve Gauss Elimination, Pitfalls of Elimination, Techniques of improving solutions, Gauss- Jordan method Matrix Invention- LU decomposition, Matrix Inversion method, Gauss Seidel, Jacobi Iteration method, System of linear equations	**5 Hrs.**
Unit 3:---A. Curve Fitting: Least Square Regression – Linear regression, Polynomial Regression Interpolation – Newton's divided difference, Interpolating polynomial, Lagrange's interpolating polynomial. B. **Mathematical Modeling .** Modeling Concept, Modeling of Physical Systems, Graphical representation of solutions to differential equations.	**8 Hrs.**

Unit 4:--- Numerical Differentiation and Integration Numerical Integration (Simpsons, Trapezoidal and Gauss Quadrature methods). Solution of Non linear equations, Applications of numerical techniques. Integration of Equation: Romberg's Integration and Gauss Quadrature. Numerical differentiation, Differentiation formulae, Derivation of unequally spaced data, Forward difference, Central difference, Backward difference Problems based on engineering application.	**7 Hrs.**
Unit 5:--- Ordinary Differential Equation: Taylor's series method, Picard's Method, Runge-Kutta method, Euler's Method, Improved polygon method, System of equation Boundary value and Eigen value problem, Finite Difference Method, Eigen value problem based on polynomial method, Determination of Eigen values by Power method, Problems based on engineering application.	**6 Hrs.**
Unit 6:--- Partial Differential Equation: Finite Difference – Elliptic equation, Laplace's equation, Liebmen's Method, Secondary variables, Boundary condition. One dimensional, two dimensional and three dimensional transient heat conduction problems in Cartesian and cylindrical co-ordinates Explicit, Implicit, Crank Nicholson Problems based on engineering application. Finite Difference- Parabolic Equation , Explicit Method- Bender- Schmidt method, Introduction of MATLAB, Mechanical Engineering Problem solving approach by using MATLAB.	**7 Hrs.**

Module wise Measurable Students Learning Outcomes :

Obtain root of given function/polynomial using numerical methods.
Solve linear simultaneous equations using numerical methods.
Analyze the data and apply numerical methods to fit a curve on the data.
Solve the complex differential and integral equations in mechanical engineering.
Solve the ODE applicable for mechanical engineering using numerical methods.
Solve the PDE applicable for mechanical engineering using numerical methods.

Textbooks:

1. Dr. B. S.Grewal, “Numerical Methods”, Khanna Publishers, New Delhi.
2. E. Balguruswamy, “Numerical Methods”, Tata Mcgraw Hill Publication Company Ltd.
3. Steven C. Chapra, “*Numerical Methods for Engineers*”, Tata McGraw Hill Publications, New Delhi
4. “Numerical Methods”, S.Arumugam, A. Thangapandi Isaac and A.Somasundaram, Scitech Publications India Pvt.Ltd.,Chennai.

References Books:

1. J.N. Kapoor, “Mathematical Modeling”,New Age Mumbai, first Edition,2005. Kreyszig, “Advanced Mathematics”,LaurieRosatone, USA.
2. S.C. Chapra, “Applied Numerical Methods with MATLAB for Engineers and Scientists”, Tata McGraw Hill Education Pvt. Ltd., New Delhi
3. Sigiresu S Rao, “Engineering Optimization”,New Age International Publisher.
4. R. L. Burden and J. D. Faires, “Numerical Analysis Theory and Applications”, Cengage Learning India Pvt. Ltd., New Delhi

TERM WORK:

Students are expected to solve and develop computer programs on each unit containing Algorithm, Flow charts, Computer code, problem with analytical treatment.

Title of the Course: Object Orientated Programming Course Code: PMDN0133	L	T	P	Credit
	-	-	2	1

Course Pre-Requisite:

Basic knowledge of Mathematics

Course Description:

The course will introduce students to Matlab through real life examples and hands on exposure. Initially the course introduce to basic Matlab commands and importing and visualizing data. The course give opportunity to try the knowledge gained in to the project to be performed at the end of the course.

Course Objectives:

1. To develop and enhance the programming skills amongst the students in general as well as application of it in the field of Mechanical Engineering.

2. To introduce analysis and visualization of Data using Matlab .

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		level	Descriptor
CO1	Apply their knowledge and programming skills to solve various computing problems in the field of Mechanical Engineering.	3	Application
CO2	Design and Develop small Matlab application to solve real time problems.	3, 6	Application, Create

CO-PO Mapping:

	PO1	PO2	PO3
CO1	1		
CO2	2		

1:low, 2:medium, 3:high

Assessments :

Teacher Assessment:

In Semester Examination (ISE) for 50 marks

Assessment	Marks

ISE	50

Course Contents:	
Unit 1:--- Overview and Commands Entering Commands, Naming Variables, Saving and Loading Variables, Using Built-in Functions and Constants, MATLAB Desktop and Editor, The MATLAB Editor, Running Scripts	**2 Hrs.**
Unit 2:--- Vectors, Matrices and Arrays Manually Entering Arrays, Creating Evenly-Spaced Vectors, Array Creation Functions, Indexing into Arrays, Extracting Multiple Elements, Changing Values in Arrays, Performing Array Operations on Vectors	**4 Hrs.**
Unit 3:--- Calling Functions Obtaining Multiple Outputs from Function Calls, Obtaining Help in Matlab	**2 Hrs.**
Unit 4:--- Plotting Data, Importing Data Plotting Vectors, Annotating Plots, Import Tool, Importing Data as a Table	**4 Hrs.**
Unit 5:--- Logical Arrays Logical Indexing, Programming Constructs, Decision Branching, For Loops	**2 Hrs.**
Textbooks: 1. Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers by Rudra Pratap 2. MATLAB and its Applications in Engineering, 2e by Bansal,Goel,Sharma	
References Books: 1. MATLAB: An Introduction with Applications, 4ed by Amos Gilat 2. Matlab and Simulink for Engg (Oxford Higher Education) by Agam Kumar Tyagi	
TERM WORK: Students are expected to solve and develop computer programs on each unit containing Algorithm, Flow charts, Computer code, problem with analytical treatment.	

Title of the Course: Research Lab	L	T	P	Credit
Course Code: PMDN0134	-	-	2	1

Course Pre-Requisite: Research methods, Research papers, Different Government Schemes

Course Description: By using different research papers available, students must identify area of interest. Based on area of interest, they must study papers and write review papers.

Course Objectives:

1. To study research papers.
2. To identify area of interest and key factors affecting research.
3. Based on area finding suitable instrument to measure readings.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		level	Descriptor
CO1	To study research paper and finding area of interest	2	Understand
CO2	To find different methods of conducting experiments.	4	Analyze
CO3	To identify schemes for procuring equipments.	4	Evaluate

CO-PO Mapping:

CO	1	2	3	4	5	6	7	8	9	10	11	12
CO1	√											√
CO2	√								√			√
CO3		√		√		√						√

Assessments :

Assessments :

Teacher Assessment:

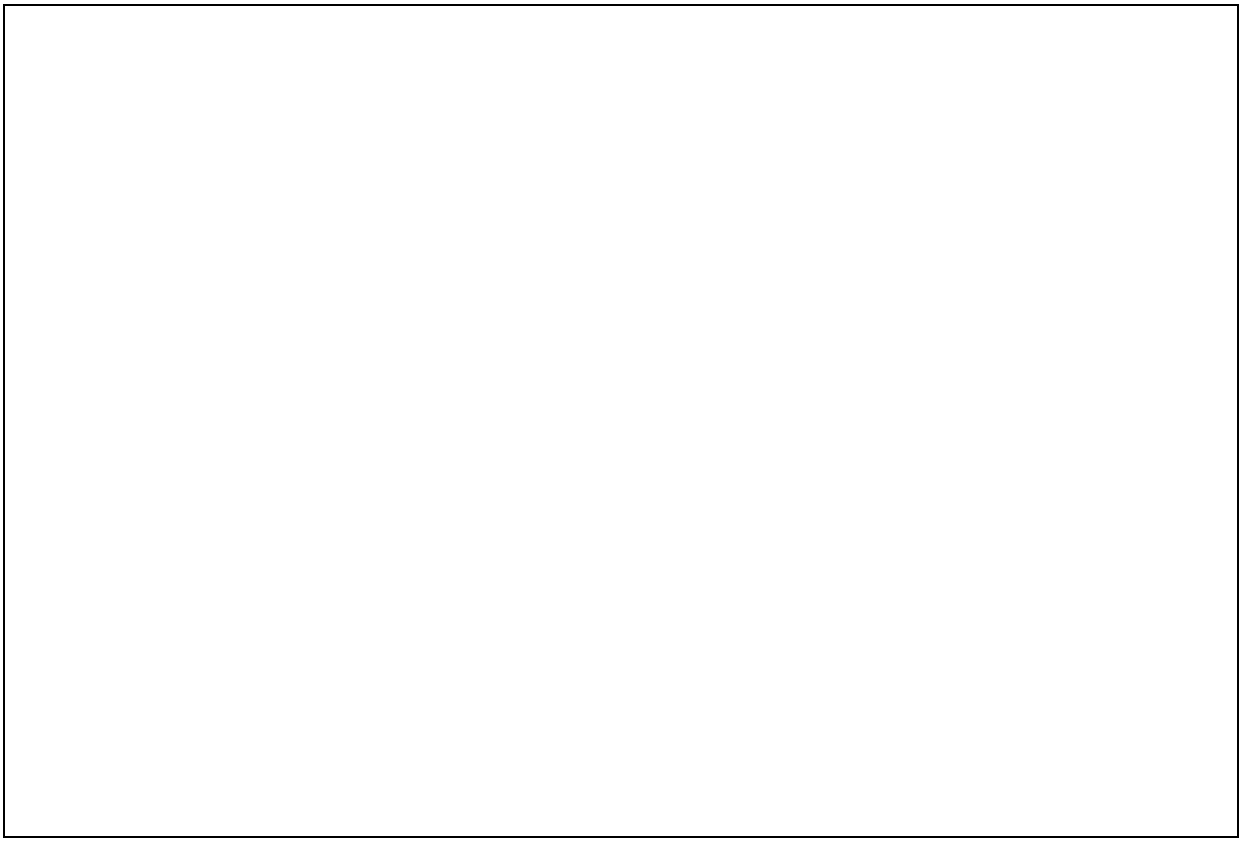
One component of In Semester Evaluation (ISE) and one End Semester Examination (ESE) having 50%, and 50% weights respectively.

Assessment	Marks
ISE	50
ESE	-

ISE are based on practical performed/ Quiz/ Mini-Project assigned/ Presentation/ Group Discussion/ Internal oral etc.

Course Contents:

Unit 1: Identify different Journal available for Mechanical Engineering.	2 Hrs.
Unit 2: Select Suitable topic as area of interest.	6 Hrs.
Unit 3: Based on selected topic, finding research completed by various authors up to date.	4 Hrs.
Unit 4: Finding new developments in area of selected topic.	4 Hrs.
Unit 5: Making presentation on selected topic.	2 Hrs.
Unit 6: Finding different schemes available from Central Government, State Government, and University for getting funds for conducting experimental work.	4 Hrs.



Title of the Course: Design for Manufacture, Assembly and Reliability Course Code:PMDN0121	L	T	P	Credit
	3	1	-	4

Course Pre-Requisite:

Fundamental knowledge of Material Science, Manufacturing Processes, Product Design and Development

Course Objectives

1. To acquire basic understanding of different design phases.
2. To study the various material selection processes, machining processes, Design considerations in manufacturing.
3. To study the general design guidelines for manual assembly and development of DFA Methodology.
4. To understand design for reliability, failure data analysis and reliability measures.

Course Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		Level	Descriptor
1	Understand various general design rules for manufacturability and criteria for material selection	II	
2	Identify the manufacturing issues that must be considered in the mechanical engineering design process	II	
3	Apply the principles of assembly to minimize the assembly time	IV	
4	Knowledge of reliability engineering.	IV	

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1			
CO2	2		
CO3			2
CO4			2

1: low, 2: medium, 3: high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30

ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/Moodle quiz/Topic seminar/Group Discussions, Industrial case study etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (Normally last three modules) covered after MSE.

Course Contents:

Unit-1 : Introduction to DFMA, History of DFMA, Steps for applying DFMA during product design, Advantages of applying DFMA during product design, Major phases of design. Effect of Material properties on Design and effect of Manufacturing Process on Design.	7Hours
Unit-2: Selection of Materials and Shapes: Properties of Engineering Materials; Material selection for product design; Selection of Shapes; Co-selection of Materials and Shapes	6 Hours
Unit-3: Selection of Manufacturing Process: Review of Manufacturing Processes; Design for Bulk Deformation Processes; Design for Sheet Metal Forming Processes; Design for Machining; Design for Powder Metallurgy; Design Considerations: Design of components with casting consideration. Pattern, Mould, And Parting line, cored holes and machined holes	8Hours
Unit-4: Assembly Processes: Review of Assembly Processes; Design for Welding; Design for Brazing and Soldering; Design for Adhesive Bonding; Design for fasteners Computer aided DFA methods, Assemblability measures.	6 Hours
Unit-5: Design for Reliability and Quality: What is Product Reliability? Typical engineering failures and their causes; Design for Quality; Design for Reliability Processes; Approach to Robust Design	6 Hours
Unit-6: Reliability function; Bathtub Curve and conditional reliability; fault trees, Failure Mode and Effect Analysis; failure rate, Mean time between failures (MTBF), Mean time to failure (MTTF); Typical forms of hazard rate function.	7Hours

Textbooks:

1. M F Ashby and K Johnson, Materials and Design - the art and science of material selection in product design, Butterworth-Heinemann, 2003.
2. G Boothroyd, P Dewhurst and W Knight, Product design for manufacture and assembly, John Wiley, NY: Marcel Dekkar, 1994.
3. HarryPeck, " DesigningforManufacturing" ,PitmanPublications,1983.

References:

1. G Dieter, Engineering Design - a materials and processing approach, McGraw Hill, NY, 2000.
2. Dieter," MachineDesign" - McGraw-HillHigherEducation, -2008
3. R.K.Jain, "EngineeringMetrology",KhannaPublishers,1986.

Title of the Course: Vehicle Dynamics	L	T	P	Credit
Course Code:PMDN0122	3	1	-	3

Course Pre-Requisite: Automobile Engineering, Dynamics of Machine, Theory of Machines.

Course Description: The course will cover following topics
Mechanical Vibrations, Loads and forces on Suspension system, tyres, Steering system, handling and stability of vehicle.

Course Objectives:
1. Demonstrate basics of automobile systems.
2. Perform mathematical analysis to predict vehicle performance.
3. Analyze the various forces acting on vehicle.
4. Analyze response of vehicle to forces.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	Explain various forces and loads on different drive trains.	II	Understanding
CO2	Identify various forces and loads on different drive trains.	III	Applying
CO3	Analyze various loads on drive train.	IV	Analyzing

CO-PO Mapping

CO	PO1	PO2	PO3
CO1	2		
CO2		2	
CO3		2	2

1:low, 2: medium, 3:high

Assessments :
Teacher Assessment:
Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:- Classification of vibration, definitions, mechanical, vibrating systems, mechanical vibration and human comfort, modeling and simulation studies. Model of an automobile, one degree of freedom, two degree of freedom systems, free, forced and damped vibrations. Magnification and transmissibility. Vibration absorber, multidegree of freedom systems-closed and far coupled systems, Orthogonality of modal shapes, modal analysis, aerodynamic-Drag, lift and side forces.	8 Hrs
Unit 2:-- Suspension: Requirements, spring mass frequency, wheel hop, wheel shimmy, choice of suspension spring rate. Calculation of effective spring rate.	7 Hrs

Vehicle suspension in fore and aft directions. Hydraulic dampers and choice of damper characteristics. Independent, compensated, rubber and air suspension systems. Roll axis and vehicle under the action of side forces.	
Unit 3:-- Steering systems : Front axle types, constructional details, front wheel geometry, Condition for True rolling, skidding, steering linkages for conventional & independent suspensions, turning radius, wheel wobble and shimmy, power and power assisted steering.	6 Hrs
Unit 4:--- Stability of vehicles: Load distribution. Stability on a curved track and on a slope. Gyroscopic effects, weight transfer during acceleration and braking, overturning and sliding. Rigid vehicle-stability and equations of motion. Cross wind handling.	**6 Hrs.**
Unit 5:--- Tyres: Types, Relative merits and demerits. Ride characteristics. Behavior while cornering, slip angle, cornering force, power consumed by a tyre. Effect of camber, camber thrust.	**6 Hrs.**
Unit 6:--- Vehicle Handling: Over steer, under steer, steady state cornering. Effect of braking, driving torques on steering, effect of camber, transient effects in cornering. Directional stability of vehicles	**7 Hrs.**

Textbooks:

1. N. K. Giri 'Automotive Mechanics' Khanna Publishers 9th Edition.
2. Moore, Desmond F "The Friction of Pneumatic Tyres."(1975)
3. Pacejka H. B. "Tyres and Vehicle Dynamics", Butterworth Hinemann.
4.Rajmani Rajesh 'Vehicle Dynamics and control', Springer

References:

1. Thomas D Gillespie, "Fundamentals of Vehicle dynamics", SAE USA 1992.
2. Thomson WT 'Theory of Vibration with Applications', CBS Publishers and Distributors, New Delhi. 1990.
3. Wong J Y, "Theory of Ground Vehicles", John Wiley & Sons, New York, 1978.
4. Cole D E, "Elementary Vehicle Dynamics", Ann Arbor, Michigan, USA, 1972.
5. Maurice Olley, "Chassis Design – Principles and Analysis", Bentley publishers.
6. J. G. Giles, 'Steering Suspension and Tyres, Illiffe Books Ltd., 1968

Unit wise Measurable students Learning Outcomes:

1. Acquire the knowledge of Various Automobile systems and different vehicle motions.
2. Analyze suspension characteristics of vehicle.
3. Analyze steering characteristics of vehicle.
4. To calculate various forces on vehicle and vehicle acceleration performance.
5. Analyze tyre properties of vehicle.
6. Acquire knowledge about ride characteristics of vehicle.

Title of the Course: Tribology in Design Course Code:PMDN0123	L 3	T 1	P -	Credit 4

Course Pre-Requisite: Engineering Mathematics, Fluid Mechanics, Machine Design, Manufacturing Process

Course Description: Tribology is the study of friction, wear and lubrication, and design of Tribological Components, science of interacting surfaces in relative motion

Course Objectives: After successful completion of this course, students will be able-

1. To Apply the basic theories of friction, wear and lubrications about frictional behavior commonly encountered sliding surfaces
2. To Select suitable/proper grade lubricant for specific application.
3. To know about properties of lubricants, modes of lubrication, additives etc.
4. To select suitable material combination for tribological contact.
5. To suggest an explanation to the cause of tribological failures.
6. To design bearing, friction, wear test rig for laboratory purposes.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Explain industrial and practical objectives of tribology Considering parameters of tribology triangle.	II	Understanding
CO2	Explain mechanisms of friction and wear for metals, alloys, Ceramics and polymers.	II	Understanding
CO3	Illustrate different types of lubrication system and methods.	II	Understanding
CO4	Apply friction/lubrication mechanism to the practical engineering problem.	III	Applying

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	1	2	3
CO2	2	1	2
CO3	3	2	2
CO4	2	1	2

1:low, 2: medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:---INTRODUCTION OF TRIBOLOGY Tribology definition, Need of Tribology, Tribology in design, Tribology in industry (Maintenance),An overview of engineering materials having potential for tribological application, Fundamentals of surface engineering,Green Tribology.	07 **Hrs.**
Unit 2:---FRICTION Friction- Origin of Friction; Friction theories; Measurement methods.	06 **Hrs.**
Unit 3:---WEAR Types of wear - adhesive, abrasive, fatigue, corrosive etc.; Testing methods; Wear	07 **Hrs.**

debris analysis; Wear reduction methods.	
Unit 4:-- LUBRICANTS AND LUBRICATION Lubricants and their physical properties- Viscosity and other properties of oils, Additives, Classification of lubricant, Selection of Lubricants, Methods of lubrication.	06 **Hrs.**
Unit 5:--- DESIGN OF TRIBOLOGICAL COMPONENTS Tribological Elements: Sliding Bearing, Journal Bearings, Rolling contact bearing, Piston, piston ring liner etc. Friction, Lubrication and wear in Clutches, Brakes, Pneumatic Tyres, Mechanical Seals, drives etc. Sliding Bearings: Thrust bearings, Journal Bearings, – Application, selection, modern developments. Rolling Contact Bearings: Bearing materials, Trouble-shooting and Bearing Problems.	07 **Hrs.**
Unit 6:--- DIAGNOSTIC MAINTENANCE AND CONDITION MONITORING Types of maintenance; Preventive and corrective Maintenance; Condition Based Maintenance and Condition Monitoring; Cost effectiveness. Different condition monitoring Techniques; Visual, performance, fluid and vibration monitoring. Fluid condition and particle monitoring; Fluid degradation and its identification methods; Chemical tests, infrared spectroscopy, calorimeter. Wear debris analysis; SOAP, Ferrography and other spectrometric analysis techniques for wear rate evaluation and interpretation. Vibration monitoring methods; Vibration data collection; Techniques; Instruments; Transducers; Commonly witnessed machinery faults diagnosed by vibration analysis.	07 **Hrs.**

Teaching assessment of Tutorials will be based on the completion of following assignments

Assignment on Introduction of Tribology.
Assignment on Friction.
Assignment on Wear.
Assignment on Lubricants & Lubrication.
Assignment on Hydrodynamic and Hydrostatic Lubrication.
Assignment on condition monitoring Techniques.

Textbooks:

1. Engineering Tribology– Prasanta Sahoo – Prentice Hall of India Pvt. Ltd., New Delhi, 2005.
2. Fundamentals of Tribology – S.K. Basu, S.N. Sengupta, B.B. Ahuja – PHI Learning Pvt. Ltd.,2010.
3. Tribology in Industries – S.K. Shrivastava – S. Chand & Company Ltd., New Delhi, 2001
4. Bearing Design in Machinery, Engineering Tribology and Lubrication - A. Harnoy- Marcel Dekker Inc., 2003

References:

1. Cameron A., Basic Lubrication Theory, Wiley Eastern Ltd.
2. Bharat Bhushan, Principles and Applications of Tribology 2nd Edition, Wiley India
3. Mujumdar B. C.,Introduction to Tribology and Bearings, S. Chand and Company Ltd. New Delhi.
4. Fuller D. D.,Theory and Practice of Lubrication for Engineers, John Wiley and Sons.
5. Halling J.,Principles of Tribology‖, McMillan Press Ltd.
6. Bhushan B. and Gupta B. K.,Handbook of Tribology: Material, Coatings and Surface Treatments, McGraw Hill Ltd.
7. Davis J.,Surface Engineering for Corrosion and Wear Resistance, Woodhead Publishing, 2001.

8. Tadausz Burakowski,Surface Engineering of Metals: Principles, Equipments and Technologies, Taylor and Francis.
9.Tribology in machine design- By -T. A. Stolarski
10.Tribology & design-edited by M. Hadfield, C. A. Brebbia, J. Seabra
11.Tribological Design of Machine Elements by D. Dowson , C.M. Taylor, M. Godet, D. Berthe

Unit wise Measurable students Learning Outcomes:

1. Summarize industrial and practical aspects of tribology.
2. Explain mechanisms of friction for metals, alloys, ceramics and polymers.
3. Illustrate various types of wear and wear measurement equipment.
4. Explain types of lubricant and regimes of lubrication.
5. Explain various mechanisms of lubrication with its significance.
6. Identify the areas of applications for tribology.

Title of the Course: Engineering fracture Mechanics Course Code: PMDN0124	L	T	P	Credit
	3	1	-	4

Course Pre-Requisite:

Analysis mechanical elements, Machine Deign, Metallurgy.

Course Description:

The focus of engineering fracture mechanics is to develop an understanding of the mechanics of fracture of engineering materials and structure under static and dynamic loading students will be taught the principles of linear elastic and elastic plastic fracture mechanics and their applications to engineering design. This course will be also introducing key applications of fracture mechanics in industry including damage detection failure analysis and experimental technique.

Course Objectives:

1. To understand the design principle of materials and structures using fracture mechanics approaches
2. To introduce the mathematical and physical principles of fracture mechanics and their applications to engineering design.
3. To prepare the students for broader applications of fracture mechanics in material testing, evaluation, characterization, and material selection.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Distinguish between crack tip opening displacement, SIF, ERR.	I	Knowledge
CO2	Develop basic fundamental understanding of the effects of crack in mechanical engineering structures.	III	Application
CO3	Select appropriate materials for engineering structures to insure damage tolerance.	IV	Analysis
CO4	Measure critical crack sizes and fatigue crack propagation rates in engineering structures.	V	Evaluation

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	3	1	
CO2		2	3
CO3	2		3
CO4	3	1	

1:low, 2:medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30

ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:Fracture mechanics principles Introduction and historical review, sources of micro and macro cracks. Stress concentration due to elliptical hole, strength ideal materials, and Griffith's energy balance approach. Fracture mechanics approach to design. NDT and Various NDT methods used in fracture mechanics, numerical problems. The Airy stress function, complex stress function, solution to crack problems, effect of finite size, special cases, elliptical cracks, numerical problems.	7 **Hrs.**
Unit 2:**Placticity** Introduction on Plasticity effects, Irwin plastic zone correction, and Dug dale approach. The shape of the plastic zone for plane stress and plane strain cases, plastic constraint factor. The thickness effect and numerical problems.	8 **Hrs.**
Unit 3:Fracture Mechanics The energy release rate, and criteria for crack growth. The crack resistance (R curve), compliance, J integral, tearing modulus and stability. Elastic Plastic Fracture Mechanics (EPFM): Fracture beyond general yield. The crack-tip opening displacement, the use of CTOD criteria, and experimental determination of CTOD. Parameters affecting the critical CTOD, use of J integral, and limitation of J integral.	7 **Hrs.**
Unit 4: Dynamic fracture Dynamics and crack arrest, Crack speed and kinetic energy. Dynamic stress intensity and elastic energy release rate. Crack branching. Principles of crack arrest. Crack arrest in practice. Dynamic fracture toughness**.**	7 **Hrs.**
Unit 5: Crack Fatigue crack propagation and applications of fracture mechanics, Crack growth and the stress intensity factor. Factors affecting crack propagation. Variable amplitude service loading means to provide fail-safety, required information for fracture mechanics approach, mixed mode (combined) loading and design criteria.	6 **Hrs.**

Unit 6: Stress intensity Determination of stress intensity factors and plane strain fracture toughness Introduction, analysis and numerical methods, experimental methods, estimation of stress intensity factors.	5 **Hrs.**

Textbooks:

1. David Broek, "Elementary Engineering Fracture Mechanics", Springer Netherlands,2011
2. Anderson , "Fracture Mechanics-Fundamental and Application", T.L CRC press1998.

References:

1. Karen Hellan , "Introduction to fracture mechanics", McGraw Hill, 2nd Edition
2. S.A. Meguid , "Engineering fracture mechanics" Elsevier Applied Science, 1989
3. Jayatilaka, "Fracture of Engineering Brittle Materials", Applied Science Publishers, 1979
4. Rolfe and Barsom , "Fracture and Fatigue Control in Structures" , Prentice Hall, 1977
5. Knott , "Fundamentals of fracture mechanisms", Butter worths, 1973.

Unit wise Measurable students Learning Outcomes:

1. **Explain the mechanism of fracture in ductile and brittle materials.**
2. **Explain the micro mechanics of brittle and ductile fracture.**
3. **Analyze the fatigue and fracture behavior and material.**
4. **Apply the knowledge for failure analysis and case studies.**
5. **Estimate cracks tip operating displacement crack detection and J integral.**
6. **Find out the stress intensity factor in structure.**

Title of the Course: Experimental Stress Analysis	L	T	P	Credit
Course Code: PMDN0125	3	1	-	4

Course Pre-Requisite:

- Strength of Material
- Theory of Elasticity

Course Description:

The course is intended to provide knowledge about different experimental stress analysis techniques. These are very much needed to validate the design outputs

Course Objectives:

1. To acquire basic understanding of Experimental stress analysis methods.
2. To acquire complete knowledge of Photoelasticity
3. To make students understand and learn about the strain gauges
4. To acquire knowledge of coating method, Holography and Moire technique

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	Perform stress strain analysis of mechanical systems using electrical resistance strain gauges	3	Applying
CO2	Know the concepts of photo elasticity and its applications.	3	Applying
CO3	Conduct stress strain analysis of solid bodies using the methods of photo elasticity	5	Evaluating
CO4	Analyze stress strain behavior of solid bodies using methods of coating and Holography	4	Analyzing

CO-PO Mapping:

CO	1	2	3
CO1	1		
CO2		2	
CO3			3
CO4			2

1:low, 2: medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc. MSE: Assessment is based on 50% of course content (Normally first three modules) ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.	
Course Contents:	
Unit 1:- **(A)Elementary Elasticity:** Introduction, stress, strain, stress at a point, principal stresses and strains, the two dimensional state of stress. **Electrical-resistance Strain Gages:** Introduction, gage sensitivity and gage factor. • Materials ,Bonding of strain gauges : surface preparation ,moisture proofing Types of bonds, • Testing of gauge installations. • Strain measuring circuits, Commercial strain indicators. • Rosette Analysis. • Strain gauge transducers. • Cross sensitivity, Temperature compensation. • Semi –Conductor strain gauges	**09 Hrs.**
Unit 2:- **Theory of Photo-elasticity:** Nature of light, wave theory of light, Intensity and interference, Stress optic law. Polari scopes: Arrangement of photo-elastic instruments in plane & circular Polari scopes, effect of stressed model in plane and circular Polari scopes, Isoclinics, Isochromatics. Numerical Examples.	**06 Hrs.**
Unit 3:- **2D Photo-elasticity:** Separation methods: shear difference method, method of using lateral extensometer, oblique incidence method. Scaling model-to-prototype stresses. Numerical Examples.	**05 Hrs.**
Unit 4:- **3D Photo-elasticity:** Stress freezing method, general slice, effective stresses .Scattered light photo elasticity: principles, polariscope and stress data analyses.	**05 Hrs.**
Unit 5:- **Photo-elastic Coating and Holography:** Coating stresses, Birefringent coatings (Photoelastic & Brittle coatings), coating sensitivity, coating materials, analysis of brittle- coating data. **Holography:** Equation for plane waves and spherical waves Intensity – Coherence – Spherical radiator as an object (record process) Hurter –	**08 Hrs.**

Driffeld curve reconstruction process General case. Holographic set up	
Unit 6:- **Moire Technique:** Geometrical approach – sensitivity of Moire data - data reduction in plane and out plane Moire methods – Moire photography – Moire grid production..	**07 Hrs.**

Textbooks:

1. Dally and Riley, "Experimental Stress Analysis". McGraw Hill.
2. Srinath, Lingaiah, Raghavan, Gargesa, Ramachandra and Pant, "Experimental Stress Analysis". Tata McGraw Hill.
3. Sadhu Singh "Experimental Stress Analysis". Hanna publisher..
4. Hand Book of Experimental Stress Analysis by Hyteneyi.

References:

1. M. M. Frocht, "Photo elasticity Vol I and Vol II. John Wiley & sons.
2. Perry and Lissner, "Strain Gauge Primer".
3. Kuske, Albrecht & Robertson "Photo elastic Stress analysis" John Wiley & Sons.
4. Dave and Adams, "Motion Measurement and Stress Analysis".
5. Hand Book of Experimental Stress Analysis". by A. S. Kobayassin (Ed), SEM/VCH,II edition.

Unit wise Measurable students Learning Outcomes:

- **The student shall be able to understand basics of Experimental stress analysis methods**
- **The student shall be able to understand Strain gauge technique**
- **The student shall be able to understand photoelasticity**
- **The student shall be able to have considerably more in-depth knowledge of the photoelasticity**
- **The student shall be able to understand the concept coating and holography**
- **The student shall be able to understand the Moire technique**

Title of the Course: Industrial Fluid Power and Automation	L	T	P	Credit
Course Code: PMDN0126	3	-	-	3

Course Pre-Requisite: Fluid Mechanics

Course Description: This course aims to impart knowledge of fluid power systems such as hydraulics and pneumatics w.r.t. their components, circuits and their applications, design of system and maintenance and troubleshooting of the system.

Course Objectives:

1. To study application of fluid mechanics and governing laws in hydraulic and pneumatic systems.
2. Study of working principle of various components used in hydraulic and pneumatic systems.
3. Study of ISO/JIC symbols of fluid power systems.
4. Selection of different components used in hydraulic and pneumatic systems.
5. Development of hydraulic and pneumatic circuits.
6. Industrial applications of hydraulic and pneumatic circuits.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	demonstrate an understanding of fluid power terms, concepts, and calculations for simple applications		
CO2	select components for application of fluid power (Hydraulics and Pneumatics) in Industries.		
CO3	use and apply hydraulic, Pneumatic and Electro hydraulic schematics to build circuits.		

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1			
CO2			
CO3			
CO4			

1:low, 2: medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc. MSE: Assessment is based on 50% of course content (Normally first three modules) ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.	
Course Contents:	
1. Fluid Power Systems: Classification, general features, applications in various fields of engineering, ISO/JIC Symbols of hydraulic and pneumatic systems, composite symbols. Hydraulic Fluids: Fluid Compressibility, Pascal's Law, Bernoulli's theorem, Temperature effects, Fluid viscosity, Hydraulic fluids and their properties, Selection of fluid.	7-**Hrs.**
2. Hydraulic System Elements: Types of hydraulic cylinders and their mountings, cylinder- force, velocity, acceleration, power and losses, cylinder loading through mechanical linkages, calculation of cylinder forces, Hydraulic motors and ratings, types of motors- torque, power and flow rates; hydrostatic transmission, Pump types and flow rates, power and efficiency, characteristics curves, Control of Hydraulic Elements: a) Pressure control valve: direction control valves, pilot operated relief, pressure reducing, quick exhaust, sequence valves, compensated valves, flow control valves and priority valves and circuits for their applications b) Direction Control Valves- Actuators for valves, two way - two position, four way - two position, four way - three position, open center, close center, tandem center, pilot operated direction control valves, check valves, intermittent feed control, deceleration, Design considerations for directional control valves c) Calculation of piston velocity, thrust under static and dynamic operation and application, considerations of friction and inertia loads	7 -**Hrs.**
3. various hydraulic circuit for different applications, Hydraulic Servo-controlled Circuits and Applications: Hydraulic servo-controlled systems - components, Servo-circuits – tracer circuit, electro-hydraulic servo-valves, proportional valves; position, velocity and force control with servo-valves, torque converters	5 -**Hrs.**
4. Pneumatics: Compressed air generation and contamination control, Effect of compressibility, Actuator functioning- thrust, cylinder air consumption, cylinder speed and flow rate, types of actuators, cylinders - types, pneumatic muscles, Rotary- air motors-types, semi-rotary actuators, Pneumatic grippers- finger like and vacuum type- suction lift force.	7 -**Hrs.**
5. Elements of Pneumatic System: Direction control valves- Actuation, two way, three way, four way, check and shuttle valves, flow control valves, pressure control valves, speed control, quick exhaust valves, solenoid, pilot operated valves, time delay valve, pressure sequence valve, pneumatic counter; Electro-pneumatics- Electrical devices like switches, relays, electronic sensors-reed switch, proximity switch, solenoid valves,	7- **Hrs.**

6. Pneumatic Circuits: Air pressure losses, Circuit design and displacement-step and –time diagram, Impulse operation, pneumatic motor circuit, sequencing of motion, latching, time delay circuit and their applications, Pneumatic servo-system for linear and rotary motion, interfacing with programmable logic controller (PLC),	5 -**Hrs.**

Textbooks:

1. "Oil hydraulics Systems", S. R. Mujumdar, Tata McGraw Hill Publication.
2. "Pneumatic Systems", S. R. Mujumdar- Tata McGraw Hill Publication.
3. "Industrial Fluid Power",D. S. Pawaskar, Nishant Prakashan.
4. "Hydraulics and Pneumatics", Shaikh and Khan, R.K. Publication.
5. "Fluid Power with Application", Esposito, Pearson Education, 7th Edition.
6. "Basic Hydraulic – Festo Manual"
7. "Basic Pneumatic – Festo Manual"
8. "Industrial Fluid Power", S.S. Kuber, Nirali Prakashan, 3rd Edition.
9. "Hydraulics and Pnuematics",Dr.Anand Bewoor, Late S.K.Ponde,Nirali Prakashan.

References:

1. "Hydraulic and Pneumatic",H.L.Stewart,Industrial Press.
2. "Industrial Hydraulic", J. J. Pipenger, Tata McGraw Hill.
3. "Power Hydraulics", Goodwin 1st Edition.
4. "Introduction to Hydraulic and Pneumatics",S. Ilango and V Soundararajan, Prentice Hall of India,
2nd Edition.
5. "Pneumatic Control",Joji P.,Wiley. , 1st Edition.
6. "Fluid Power",Jagadeesha T. , Wiley Publications.
7. Eaton (Vickers) Manual.
8. Product Manuals and books from Vickers/ Eaton, FESTO, SMC pneumatics..

Unit wise Measurable students Learning Outcomes:

After completion of units , students are able to:

Understand the fluid power symbols used in hydraulics and pneumatics, various control elements required in hydraulics and pneumatics, different circuits in hydraulics and pneumatics.

Title of the Course: Product Design Development	L	T	P	Credit
Course Code: PMDN0127	3	-	-	3

Course Pre-Requisite: Knowledge of Machine Drawing, Computer Aided Drafting and Manufacturing Engineering

Course Description: The course is focused on Product Design and development process through innovative ideas, screening of such ideas, feasibility study and building reliable product by gathering needs from the consumers. This course motivates and educates students to develop new products for betterment of society. This course is also useful for young entrepreneurs for converting their ideas into commercial product through systematic product development procedure.

Course Objectives:

1. To educate students to conceptualize and evaluate ideas to create new products by combining art, science and technology.
2. To introduce students to product architecture and prototyping.
3. To estimate costing for a new product and study cost dynamics.
4. To aware students about impacts of developed products from patent and intellectual property point of view.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	**Demonstrate** knowledge of integration of design aspects like product architecture, ergonomics, aesthetics, quality, safety, reliability and product data management.	2	Understand
CO2	**Develop** different alternative solutions for small sub problems and **select** most appropriate solution from the set of solutions.	3	Apply
CO3	**Estimate** cost of new product by considering various components of the costs.	5	Evaluate
CO4	**Interpret** the process of Patenting the design.	2	Understand

CO-PO Mapping:

CO\PO	1	2	3
CO1	1	2	2
CO2			1
CO3			1
CO4		1	2

1: low, 2:medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules).
ESE: Assessment is based on 100% course content with 60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1: --- Introduction Challenges of product development, Identify customer needs, Successful product development, Quality aspect of product design, Market Research, Survey.	6 **Hrs.**
Unit 2: --- Product Development Process and Planning Innovation and Creativity in Product Design, Product Planning Processes, Product Specifications: Process of setting specifications. (Concept Generation–Selection–Testing).	7 **Hrs.**
Unit 3: --- Product Architecture Product Architecture: Implication of architecture, Establishing the architecture, Related system level design issue, Product Data Management, Use of Computerized Data Management and Process, Industrial Design: Overview.	7 **Hrs.**
Unit 4: --- Design for X Methodology Rules, guidelines, and methodologies along the product life cycle phases: Development phase, Production phase, Use phase, Disposal phase, **Product Costing:** Different costs, Pre-requisites for cost accounting, Volume-Varity matrix and its impact on product costing, Value engineering.	7 **Hrs.**
Unit 5: --- Design Organization : Organization structure, Designers position, Drawing office procedure, Standardization, Record keeping,	6 **Hrs.**
Unit 6: --- Patents and Intellectual Property: What is Intellectual Property? Seven step procedure of IP. Formulate a strategy and Plan, Study Prior Inventions, Outline Claims, Write the Description of the Invention, Refine Claims, Pursue Application, Reflect on the Result and the Process.	7 **Hrs.**

Textbooks:

1. "Product Design and Development", Karl T. Ulrich, Steven G. Eppinger; Irwin Tata McGraw Hill, 3rd Edition.
2. "Product Design and Manufacturing",A.C. Chitale and R.C. Gupta, Prentice Hall of India, 3rd Edition.
3. "Product Design",Otto and Wood, Pearson education.

References:

1. "Introduction to Ergonomics",R.C. Bridger, Tata McGraw Hill Publication.
2. "New Product Development", Tim Jones, Butterworth, Heinemann, Oxford, (1997).
3. "Industrial Design for Engineers",Mayall W.H, London, Hiffee books Ltd.

Title of the Course: Mechatronics System Design	L	T	P	Credit
Course Code: PMDN0128	3	-	-	3

Course Pre-Requisite:

1. Fundamentals of Electronics
2. Electrical Machines and Electronics

Course Description:

Mechatronics refers to a flexible, multi-technological approach for integration of mechanical engineering, computer engineering, electronics and information sciences. Mechatronics is essential in the design of intelligent products. It allows engineers to transform their virtual concepts into real life applications. It is a relatively new concept relating to the design of systems, devices and products aimed at achieving an optimal balance between basic mechanical structure and its overall control.

Course Objectives:

1. Be able to work efficiently in multidisciplinary teams.
2. Be able to apply mechanical engineering and electrical engineering knowledge and skills to problems and challenges in the areas of mechatronic engineering.

3.Be able to classify different sensors

4. Be able to construct PLC ladder program for given application

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	Explain different types of control systems	II	Explain
CO2	Classify different signal conditioning tech.	IV	Classify
CO3	Construct PLC ladder program	III	Construct
CO4	Select appropriate microcontroller for given application	III	Select
CO5	Explain various types of Micro manufacturing processes.	II	Explain
CO6	Design a mechatronic system for given application	VI	Design

CO-PO Mapping:

	PO1	PO2	PO3
CO1	1		
CO2	1		
CO3		1	2
CO4			2

CO5	1		
CO6		1	2

1:low, 2: medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:--- A) I**ntroduction**: Introduction to mechatronic system, evolution, scope and components of mechatronic systems, mechatronics in product and measurement system, control system and modes of control, traditional design and mechatronic design, Integrated design approach for Mechatronics system. B) Actuators, Sensors and Transducers: Hydraulic, pneumatic and electrical actuators and their system modeling, performance terminology, system modeling of sensors; displacement, position and proximity sensors, velocity and acceleration sensors, flow sensors, force sensors, temperature sensors, ultrasonic and fibre-optic sensors, encoders.	8 **Hrs.**
Unit 2:--- **Signal Conditioning**: Signal conditioning processes, clock signal, voltage divider, rectification, Operational Amplifiers: inverting and non-inverting, summing, integrating, differential, logarithmic, comparator, sample and hold, analog to digital and digital to analog converters, multiplexing and de-multiplexing	6 **Hrs.**
Unit 3:--- **Programmable Logic Controller:** Review of logic gates, basic structure, features, input/output processing, programming, functional block diagram (FBD), ladder diagram, logic functions, latching, sequencing, jumps, internal relays, counters, shift registers, master and jump control, data handling, data movement, data comparison, arithmetic operations, code conversion, analog input and output, applications for automation, diagnostics and condition monitoring.	6 **Hrs.**
Unit 4:--- **Microcontroller:** Comparison between microprocessor and microcontroller, organization of microcontroller system, architecture of MCS 51 controller, pin diagram of 8051, addressing modes, programming of 8051, introduction to Proteus and Keil software, programming of 8051 for simple applications using Proteus and	7 **Hrs.**

Keil, interfacing input and output devices, interfacing D/A converters and A/D converters, Various applications for automation and control purpose.	
Unit 5:--- **MEMS and Advanced Applications in Mechatronics:** Overview of MEMS and Microsystems, typical MEMS and Micro system products and applications. (i) Micro sensors and micro actuators: phototransistors, pressure sensors, thermal sensors, micro grippers, micro motors, micro valves, micro pumps (ii) Micro-manufacturing: bulk manufacturing, surface manufacturing, LIGA process. Advanced Applications in Mechatronics: Mechatronic control in automated manufacturing, Artificial Intelligence in mechatronics, Introduction to Fuzzy logic, Fuzzy Logic application in Mechatronics	8 **Hrs.**
Unit 6:--- **Design of Mechatronic systems**: The design process, traditional and mechatronic designs, A few case studies like piece counting system, pick and place manipulator, simple assembly task involving a few parts, part loading / unloading system, automatic tool and pallet changers etc.	5 **Hrs.**

Textbooks:

1. Mechatronics 3/e - W. Bolton (Addison Wesley) ISBN 81-7758-284-4
2. Mechatronics Principles, Concepts & Applications – N.P.Mahalik (TMH) ISBN 0-07-0483744
3. Ogata – Modern Control Engineering (Pearson Education) ISBN 81-7808-579-8
4. Industrial Automation – David. W. Pessen (John Wiley & Sons) ISBN 9971- 51-054-5.
5. Automated Manufacturing Systems: Sensors, Actuators – S. Brain Morriss (McGraw Hill) ISBN 0-07-113999-0
6. MEMS & Microsystems Design & Manufacture – Tai – Ran Hsu – TMH 0-07-048709.
7. MEMS – Mahalik, N.P. (TMH) ISBN :13 978-0-07-063445-9
8. Webb and Reis,"Programmable Logic Controller – Principles and Applications",Prentice Hall of India,2002.

References:

1] Mechatronics – Dan Necsulescu (Pearson Education) ISBN 81-7808 -676 – X. 8. The 8051 Microcontroller: Architecture, Programming & Applications, 2/e – Kenneth J. Ayala (Penram International) ISBN – 81-900828-7

2] Introduction to Mechatronics & Measurement System – David G. Alciatore & Michael B. Histand (TMH) ISBN 0-07-052908

Unit wise Measurable students Learning Outcomes:

1. **The student shall be able to understand different control systems and select appropriate sensor for given application**
2. **The student shall be able to understand different signal conditioning tech**
3. **The student shall be able to construct a PLC ladder program for given application**

4. **The student shall be able to understand applications of microcontroller**
5. **The student shall be able to understand applications of MEMS**
6. **The student shall be able to design a mechatronic system for given application**

Title of the Course: Rapid Prototyping	L	T	P	Credit
Course Code: PMDN0129	3	-	-	3

Course Pre-Requisite: Knowledge of 3D Modeling and surface modeling is essential

Course Description: With explosive growth of AM along with consumer interests, so many unique and interesting application areas are being developed. The objective of the course is to develop an understanding of the principles of the current additive manufacturing processes that produce parts by a layer at a time from solid 3D computer model so that optimal geometry, machine, and material can be selected to satisfy the functional requirement of the designed shape. The course will conclude with a perspective in pushing the current envelop of AM spanning many technical domains such as biomedical, aerospace, biotechnology industries.

Course Objectives:

1. To describe the current available Additive Manufacturing systems, their fundamental operating
principles, characteristics and limitations.
2 To Distinguish between traditional and Rapid Manufacturing process.
3. To Explain the principles and key characteristics of commonly used processes in additive manufacturing.
4.To Select the appropriate materials and rapid prototyping processes for a given prototyping task
5. To Apply criterion for selecting appropriate additive manufacturing process for any given application in the areas like automotive, aeronautics, tooling and biomechanics etc.
6. To Select appropriate Additive Manufacturing Process in the area of tooling. and apply various parameters in slicer software and generate program to carry out the 3D Printing operation on machine..

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Describe the current available Additive Manufacturing systems, their fundamental operating principles, characteristics and limitations.	II	Describe
CO2	Distinguish between traditional and Rapid Manufacturing process and assess impact of AM on DFMA..	IV	Distinguish
CO3	Explain the principles and key characteristics of commonly used processes in additive manufacturing.	II	Explain
CO4	Select the appropriate materials and rapid prototyping processes for a given prototyping task	V	Select
CO5	Apply criterion for selecting appropriate additive manufacturing process for any given application in the areas like automotive, aeronautics, tooling and biomechanics etc.	V	Apply
CO6	Select appropriate Additive Manufacturing Process in the area of tooling. and apply various parameters in slicer software and generate program to carry out the 3D Printing operation on machine..	V	Select

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	1		
CO2		1	
CO3			3
CO4	1		2
CO5	3		
CO6	2		

1:low, 2: medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1: Introduction to Additive Manufacturing: Definition of additive manufacturing (AM), and rapid manufacturing, Introduction to Solid Freeform Fabrication, areas of application. Historical development, Fundamentals of Additive manufacturing, Advantages and Limitations of Additive manufacturing, Commonly used Terms, Classification,	6 **Hrs.**
Unit 2:--- Unit 2: Design Potential and management issues of Additive Manufacturing: Difference between conventional and Additive manufacturing process, Conventional design for manufacturing and assembly (DFM, DFMA), impact of AM on DFA and DFMA, Geometrical freedom, design complexity/ optimization, parts consolidation, body fitting customization and multiple assemblies manufactured as one, Customer input and customization, CAD environment for AM. Machine costs for AM, material cost, labor cost, comparison of cost of RM with cost of injection molding; Cost of manufacturing by AM,	6 Hrs.
Unit 3:--- Unit 3: Additive Manufacturing Processes: Liquid based processes, Powder based processes and Solid based processes; Process overviews, STL file Generation, File Verification & Repair, Part Construction, Part Cleaning and finishing, Process Strength & limitations, 1. Liquid-Based Systems: (Stereolithography) 2. Solid-Based Systems: (Fused Deposition Modeling, Laminated Object 3. Manufacturing, Ultrasonic Consolidation, Polyjet) 4. Powder-Based Systems: (Selective Laser Sintering, Laser Engineered Net 5. Shaping, Electron Beam Melting) 6. Bioprinting	6 Hrs.

Construction, working principal, Applications, Benefits and Limitations of above processes	
Unit 4:--- Unit 4: Materials in RM: viscous flow, photo-polymerization, sintering, infiltration, mechanical properties, Materials for AM processes, Prototype properties: Material properties, color, dimensional accuracy, stability, surface finish, machinability, environmental resistance, operational properties; Functionally graded materials (FGM composites), processing technologies for FGMs, thermal and mechanical properties of FGM, Deposition systems and applications,	6 Hrs.
Unit 5:--- Unit 5: Applications of AM: Design, Concept Models, Form and fit checking, Ergonomic Studies, Functional testing, Applications in Automotive, Aerospace industry, Construction industry, Archeology, Paleontology and forensic science, miniaturization, Biomechanics, Medical Field.	5 Hrs.
Unit 6:--- Unit 6: a) Rapid Tooling: Mold making, Metal spraying, Rapid tooling for die, squeeze and permanent mold casting, Rapid manufacturing of sheet metal forming tools, casting pattern plates by rapid tooling, RP for series production investment casting. b) Basic hardware of typical Fused Deposition Modeling 3D Printers, Construction, Generation of stl file format from CAD file, Generation of Program code for 3D Printers using appropriate available software package, Selection of appropriate parameters like layer thickness, fill density, nozzle temperature, bed temperature etc., Execution of program on 3D printer to manufacture a actual part on typical 3D Printer.	7 Hrs.

Textbooks:

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 0-470-01613-2 Pereira, J.A. Pérez, J.L. Diéguez, G. Peláez and J.E. Ares,
2. "Design and anufacture of casting pattern plates", by rapid tooling, Archives of Materials Science, Vol. 29, No. 1-2, 2008 63
3. Rafiq Noorani, Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley & Sons, 2006.

References:

1. Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, 2nd Ed. (2015), Ian Gibson, David W. Rosen, Brent Stucker.
2. Laser Additive Manufacturing of High-Performance Materials, Dongdong Gu, Springer Publ. 2014
3. Understanding Additive Manufacturing, Andreas Gebhardt, Hanser Publishers, 2011.
4. Chua Chee Kai., Leong Kah Fai., Chu Sing Lim, Rapid Prototyping: Principles and Applications in Manufacturing, World Scientific, 2010.
5. Ian Gibson., David W Rosen., Brent Stucker., Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, 2010.

Unit wise Measurable students Learning Outcomes:

1. Students shall be able to describe the current available Additive Manufacturing systems,

their fundamental operating principles, characteristics and limitations.
2. Students shall be able to Distinguish between traditional and Rapid Manufacturing process.
3. Students shall be able to Explain the principles and key characteristics of commonly used processes in additive manufacturing.
4. Students shall be able to Select the appropriate materials and rapid prototyping processes for a given prototyping task
5. Students shall be able to Apply criterion for selecting appropriate additive manufacturing process for any given application in the areas like automotive, aeronautics, tooling and biomechanics etc.
6. Students shall be able to Select appropriate Additive Manufacturing Process in the area of tooling.

Title of the Course: DESIGN OF THERMAL SYSTEMS Course Code: PMDN0130	L	T	P	C
	3	-	-	3

Course Pre-Requisite: Applied Thermodynamics, Fluid Mechanics, Heat & Mass Transfer, Refrigeration and Air-conditioning.

Course Description:

This subject enables the student to understand the different components, accessories and controls used in refrigeration systems. The students will be able to understand mathematical formulation of components as well as a whole thermal system. The students will be able to estimate the heat load calculations for refrigeration applications and will be able select or design appropriate components.

Course Objectives:

1. Learn thermal system design methodology.
2. Learn mathematical formulation of components as well as a whole thermal system
3. Learn estimation of heat load calculations for refrigeration applications.
4. Design simple thermal systems.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	Apply knowledge of mathematics, science, and engineering for mathematical formulation of components as well as a whole thermal system.	III	Applying
CO2	Analyze the heat load calculations for refrigeration applications	IV	Analyze
CO3	Design simple thermal systems.	V	Design

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	3		
CO2	3	2	
CO3			3

1:low, 2: medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1: Introduction to Thermal System Design:	6Hrs.

Thermal systems used in practice, Classification of design, Optimal and nearly optimal design, Methodology of design, Aspects of thermal system design, Assessment concept and creation, mathematical formulation component level and system level by first law of thermodynamics [energy balance basis].	
Unit 2. Design of Refrigeration System: Types of components used in VCRC, controls, accessories, their functions, salient features, applications, heat load calculations and design of basic components of refrigeration systems, Design of refrigeration systems - Household refrigerator, Ice plant, Cold storage, refrigerated vehicle, Vapour absorption systems.	**9 Hrs.**
Unit 3: Design Analysis of Air Conditioning System: Design of Air conditioning systems: Design considerations, Load calculations, Single unit room air-conditioner, Central air conditioning plant, Industrial drying systems, Component selection.	**5 Hrs.**
Unit 4: Design of Solar System Design of solar assisted water heating systems, applications of solar energy, types of solar collectors, Preliminary specifications, Concepts development, Component design.	**6Hrs.**
Unit 5: Heat Exchanger Networking & Advanced Cooling Systems: Design of advanced heat exchanger networks, Design of electronic miniature cooling systems, Utilization of Nano- Fluids for cooling systems, Design of waste heat recovery systems.	**6 Hrs.**
Unit 6: Exergy Analysis: Concept of exergy, Physical exergy and Chemical exergy, Exergy analysis for control region, Exergy concepts for closed systems, Exergy efficiency, Grassmann diagram .	**8Hrs.**

Textbooks:

1. "Thermal Design & optimization", Adrian Bejan, George Tsatsaronis, Michael Moran, JOHN WILEY & SONS INC.
2. "The Exergy Method of Thermal Plant Analysis", T. J. Kotas, British Library Cataloguing in Publication Data.
3. "Exergy, Energy, Environment and Sustainable Development ", Ibrahim Dincer, Marc A. Rosen
4. "Handbook of Process Heat Transfer", Hewitt

References:

1. "HVAC System Design Handbook" ASHRAE.
2. "Design and Optimisation of Thermal Systems", Yogesh Jalurkar, CRC Press.
3. "Design and Simulation of Thermal Systems", N.V. Suryanarayana, Oner Arici, Tata Mc Graw Hill Inc.
4. "Thermal System Design",Stoecker, Tata McGrew Hill Publication, 3rd Edition.

Title of the Course: Industrial Fluid Power and Automation Lab	L	T	P	Credit
Course Code: PMDN0136	-	-	2	1

Course Pre-Requisite: Fluid Mechanics

Course Description: This course aims to impart knowledge of fluid power systems such as hydraulics and pneumatics w.r.t. their components, circuits and their applications, design of system and maintenance and troubleshooting of the system.

Course Objectives:

1. Study of working principle of various components used in hydraulic and pneumatic systems.
2. Study of ISO/JIC symbols of fluid power systems.
3. Study of hydraulic and pneumatic circuits.
4. Design of hydraulic and pneumatic circuits for given application.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	**Explain** and **demonstrate** basic structure and elements of hydraulic and pneumatic systems.	2	Understanding
CO2	**Explain** and **demonstrate** construction and working of various elements of hydraulic and pneumatic system.	2	Understanding
CO3	**Construct** and **demonstrate** hydraulic and pneumatic circuits.	3	Applying
CO4	**Design** the hydraulic or pneumatic system for given industrial application.	6	Creating

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	2		
CO2	2		
CO3		2	3
CO4		2	3

Assessments :

Teacher Assessment:

One component of In Semester Evaluation (ISE) and one End Semester Examination (ESE) having 50%, and 50% weights respectively.

Assessment	Marks
ISE	25

ISE are based on practical performed/ Quiz/ Mini-Project assigned/ Presentation/ Group Discussion/ Internal oral etc.

ESE: Assessment is based on oral examination

Course Contents:

Experiment No. 1: Study and Demonstration of layouts of hydraulic and pneumatic system	**02 Hrs.**
Experiment No. 2: Study of ISO/JIC Symbols for hydraulic and pneumatic systems.	**02 Hrs.**
Experiment No. 3: Study and Demonstration of different types of control valves used in hydraulic and pneumatic system.	**02 Hrs.**

Experiment No. 4: Preparation of following circuits on hydraulic circuit trainer; a) Basic hydraulic circuit to obtain motions of linear and rotary actuators. b) Speed control circuits c) Sequencing circuit d) Synchronization circuits e) Counterbalancing circuits	**02 Hrs.**
Experiment No. 5: Preparation of at least two circuits on electro-hydraulics circuit trainer	**02 Hrs.**
Experiment No. 6: Preparation of following circuits on pneumatic circuit trainer; a) Automatic reciprocating motion circuits b) Speed control circuits c) Sequencing circuits (travel dependent) d) Circuit involving use of shuttle valve (OR logic circuit) e) AND logic circuit	**02 Hrs.**
Experiment No. 7: Circuit preparations (at least two) by using Fluid Simulation Software.	**02 Hrs.**
Experiment No. 8: Design of hydraulic / pneumatic system and related components for any one of selected industrial/agriculture /any suitable application. Design report should include following points like load, pressure and flow calculations, sizing and selection of components, design constraints considerations, circuit preparation and determination of energy losses in system.	**04 Hrs.**

Textbooks:

1. "Oil hydraulics Systems", S. R. Mujumdar, Tata McGraw Hill Publication.
2. "Pneumatic Systems", S. R. Mujumdar- Tata McGraw Hill Publication.
3. "Industrial Fluid Power",D. S. Pawaskar, Nishant Prakashan.
4. "Hydraulics and Pneumatics", Shaikh and Khan, R.K. Publication.
5. "Fluid Power with Application", Esposito, Pearson Education, 7th Edition.
6. "Basic Hydraulic – Festo Manual"
7. "Basic Pneumatic – Festo Manual"
8. "Industrial Fluid Power", S.S. Kuber, Nirali Prakashan, 3rd Edition.
9. "Hydraulics and Pnuematics",Dr.Anand Bewoor, Late S.K.Ponde,Nirali Prakashan.

References:

1. "Hydraulic and Pneumatic",H.L.Stewart,Industrial Press.
2. "Industrial Hydraulic", J. J. Pipenger, Tata McGraw Hill.
3. "Power Hydraulics", Goodwin 1st Edition.
4. "Introduction to Hydraulic and Pneumatics",S. Ilango and V Soundararajan, Prentice Hall of India, 2nd Edition.
5. "Pneumatic Control",Joji P.,Wiley. , 1st Edition.
6. "Fluid Power",Jagadeesha T. , Wiley Publications.
7. Eaton (Vickers) Manual.
8. Product Manuals and books from Vickers/ Eaton, FESTO, SMC pneumatics.

Experiment wise Measurable students Learning Outcomes:

1. Explain and demonstrate the structure and layouts of hydraulic and pneumatic systems.
2. Make use of ISO symbols of fluid power systems to represent the system.
3. Explain and demonstrate construction and working of various types of control valves used in hydraulic and pneumatic system.
4. Construct and demonstrate hydraulic circuits on circuit trainer.

5. Construct and demonstrate electro- hydraulic circuits on circuit trainer.
6. Construct and demonstrate pneumatic circuits on circuit trainer.
7. Make use of fluid simulation software.
8. Design the hydraulic or pneumatic system for the given application.

Title of the Course: : Product Design and Development	L	T	P	Credit
Course Code: PMDN0137	-	-	2	1

Course Pre-Requisite: Knowledge of 3D modeling is essential

Course Description: Product Design and Development is a course that covers modern tools and methods for product design and development. Topics include identifying customer needs, concept generation, product architecture, industrial design, design-for-manufacturing and product lifecycle management

Course Objectives:

To explain the concept and general process of product design and development
2. To analyze the customer needs and generate appropriate product concepts.
3.To Select the appropriate Product concept out of few generated and test these product concepts for intended function
4.To tear down the existing product and carry out benchmarking process.
5.To design the product for Manufacturing, assembly and environment concerns.
6.To Explain the concept of product lifecycle management, intellectual property rights and patents.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	Explain Product Design & Development process from its first stage of customer needs to last stage.	2	Explain
CO2	Develop the appropriate product concept after analyzing customer need.	3	Develop
CO3	Select the appropriate concept and test the concept for intended function of the product.	5	Select
CO4	Dissect the existing product to analyze the function .	4	Dissect
CO5	Design the product for Manufacturing, assembly and environment concerns.	6	Design
CO6	Explain the concept of product lifecycle management, intellectual property rights and patents	2	Explain

CO-PO Mapping:

CO	a	b	c	d	e	f	g	h	i	j	k
CO1	√	√									√
CO2						√					√
CO3						√					√
CO4											√
CO4	√										√
CO5						√			√		√
CO6						√	√				√

Assessments :

Teacher Assessment:

One component of In Semester Evaluation (ISE) and one End Semester Examination (ESE) having 50%, and 50% weights respectively.

Assessment	Marks

ISE	50
ESE	50

ISE are based on practical performed/ Quiz/ Mini-Project assigned/ Presentation/ Group Discussion/ Internal oral etc.
ESE: Assessment is based on oral examination

Course Contents:

Assignment No.1: Introduction to Product design and development and Study of Methods to gather customer needs and various methods of concept generation	3 **Hrs.**
Assignment No.2: Study of selection, testing and embodiment of concepts along with product teardown and benchmarking process**.**	3 **Hrs.**
Assignment No 3: Concept of Design for Manufacture, Assembly and Environment along with its guidelines.	3 **Hrs.**
Assignment No 4: Introduction to Product Life Cycle Management, Intellectual Property Rights and patents	3 **Hrs.**
Assignment No 5: Case Study on any TWO Commercially available products (by a group of 02 students to be presented in front of all students) covering following points, a) Customer Need, b) Product Development Process / Planning. c) Product Architecture. d) Design for Manufacturing. e) Design for Assembly. f) Environmental Safety and ISO 14000 Systems.	6 **Hrs.**
Assignment No 6:--- Development of any Product using high end CAD software considering following points. a) Need of Customer, Methodology of Market Survey. b) Invention / Innovation of a product with modifications required. c) Preparation of various Views of the product. d) Design for Assembly Procedures . e) Product and Maintenance Manual. f) Product Database Management . A report should be prepared with details, drawing sheet, Bill of Material, Assembly–Disassembly Procedure, Maintenance Manual and Cost Estimation (if required) . Presentation of the product designed.	6 **Hrs.**

Textbooks:

1. “Product Design and Development”,Karl T. Ulrich, Steven G. Eppinger; Irwin Tata McGraw Hill, 3 rd Edition.
2. “Product Design and Manufacturing”,A.C. Chitale and R.C. Gupta, Prentice Hall of India, 3 rd Edition.
3. “Product Design Techniques in Reverse Engineering and New Product Development” Kevin Otto and Kristin Wood, Pearson Education Inc.
4. “Product Lifecycle Management: Paradigm for 21st Century Product Realisation” Stark, John, Springer-Verlag, 2004. ISBN 1852338105.

References:

1] “New Product Development”, Tim Jones, Butterworth, Heinemann, Oxford, (1997).
2] “Industrial Design for Engineers”,Mayall W.H, London, Hiffee books Ltd.
3] “ Handbook of Product Design for Manufacturing”, Bralla, James G, McGraw Hill Pub.1986

Experiment wise Measurable students Learning Outcomes:

1 Students shall be able to explain Product Design & Development process and Develop the appropriate product concept after analyzing customer need

2.Students shall be able to Select the appropriate concept and test the concept for intended function of the product and Dissect the existing product to analyze the function

3.Students shall be able to Design the product for Manufacturing, assembly and environment concerns.

4.Students shall be able to Explain the concept of product lifecycle management, intellectual property rights and patents.

5.Studnets shall be able to analyze existing product considering various points as case study

6. Students shall be able to design a new product by applying all the criteria.

Title of the Course: Mechatronics System Design Lab Course Code: PMDN0138	L	T	P	Credit
	-	-	2	1

Course Pre-Requisite:

1. Fundamentals of Electronics
2. Electrical Machines and Electronics

Course Description:

Mechatronics refers to a flexible, multi-technological approach for integration of mechanical engineering, computer engineering, electronics and information sciences. Mechatronics is essential in the design of intelligent products. It allows engineers to transform their virtual concepts into real life applications. It is a relatively new concept relating to the design of systems, devices and products aimed at achieving an optimal balance between basic mechanical structure and its overall control.

Course Objectives:

1. Be able to work efficiently in multidisciplinary teams.
2. Be able to apply mechanical engineering and electrical engineering knowledge and skills to problems and challenges in the areas of mechatronic engineering.

3.Be able to classify different sensors

4. Be able to construct PLC ladder program for given application

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Explain different types of control systems	II	Explain
CO2	Classify different signal conditioning tech.	IV	Classify
CO3	Construct PLC ladder program	III	Construct
CO4	Select appropriate microcontroller for given application	III	Select
CO5	Explain various types of Micro manufacturing processes.	II	Explain
CO6	Design a mechatronic system for given application	VI	Design

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2													
CO2				2										
CO3		1	3		2				1			1	2	
CO4		1	2										1	
CO5	2													
CO6		2	3		1							1		

Assessments :

Teacher Assessment:

One components of In Semester Evaluation (ISE) and one End Semester Examination (ESE) having 50 marks each

Assessment	Marks	Min of Passing
ISE	50	20
ESE (P.O.E)	50	20

ISE is based on lab experiment.

ESE: Assessment is based on Practical and Oral examination based on 100% course content

Course Contents:

Experiment No. 1 To study the Basic Logic Gates and Universal Logic Gates using bread board **Outcome :** Able to understand the Basic Logic Gates and Universal Logic Gates	**2 Hrs.**
Experiment No. 2 To study the Inverting OPAMP **Outcome :** Able to learn the working of Inverting OPAMP	**2 Hrs.**
Experiment No. 3 To study the Non inverting OPAMP **Outcome :** Able to learn the working of Non inverting OPAMP	**2 Hrs.**
Experiment No. 4 Addition and subtraction of two 8 bit numbers using 8051 microcontroller **Outcome :** Able to learn working of microcontroller	**2 Hrs.**
Experiment No. 5 Stepper motor interfacing using microprocessor **Outcome :** Able to understand interfacing with microprocessor	**2 Hrs.**
Experiment No. 6 PLC Programming – Basic Gates **Outcome :** Able to understand basics of ladder programming	**2 Hrs.**
Experiment No. 7 PLC Programming – Sequencing **Outcome :** Able to understand advanced concept in ladder programming	**4 Hrs.**
Experiment No. 8 Mini project to demonstrate the working of various sensors **Outcome :**Able to select appropriate sensor for given application	**2 Hrs.**

Textbooks:

1. Mechatronics 3/e - W. Bolton (Addison Wesley) ISBN 81-7758-284-4
2. Mechatronics Principles, Concepts & Applications – N.P.Mahalik (TMH) ISBN 0-07-0483744
3. Ogata – Modern Control Engineering (Pearson Education) ISBN 81-7808-579-8
4. Industrial Automation – David. W. Pessen (John Wiley & Sons) ISBN 9971- 51-054-5.
5. Automated Manufacturing Systems: Sensors, Actuators – S. Brain Morriss (McGraw Hill) ISBN 0-07-113999-0
6. MEMS & Microsystems Design & Manufacture – Tai – Ran Hsu – TMH 0-07-048709.
7. MEMS – Mahalik, N.P. (TMH) ISBN :13 978-0-07-063445-9
8. Webb and Reis,"Programmable Logic Controller – Principles and Applications",Prentice Hall of India,2002.

References:

1] Mechatronics – Dan Necsulescu (Pearson Education) ISBN 81-7808 -676 – X. 8. The 8051 Microcontroller: Architecture, Programming & Applications, 2/e – Kenneth J. Ayala (Penram International) ISBN – 81-900828-7

2] Introduction to Mechatronics & Measurement System – David G. Alciatore & Michael B. Histand (TMH) ISBN 0-07-052908

Unit wise Measurable students Learning Outcomes:

1. The student shall be able to understand different control systems and select appropriate sensor for given application
2. The student shall be able to understand different signal conditioning tech
3. The student shall be able to construct a PLC ladder program for given application
4. The student shall be able to understand applications of microcontroller
5. The student shall be able to understand applications of MEMS
6. The student shall be able to design a mechatronic system for given application

Title of the Course: Rapid Prototyping Lab Course Code: PMDN0139	L	T	P	Credit
	-	-	2	1

Course Pre-Requisite: Knowledge of 3D Modeling and surface modeling is essential

Course Description: With explosive growth of AM along with consumer interests, so many unique and interesting application areas are being developed. The objective of the course is to develop an understanding of the principles of the current additive manufacturing processes that produce parts by a layer at a time from solid 3D computer model so that optimal geometry, machine, and material can be selected to satisfy the functional requirement of the designed shape. The course will conclude with a perspective in pushing the current envelop of AM spanning many technical domains such as biomedical, aerospace, biotechnology industries.

Course Objectives:

1. To generate Solid / Surface model And converting it into .STL format
2. To generate the layer of stl file and applying various priting parametres in Slicer Software and generate its program
3.Study the working of 3D Printer and print the object on machine

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	Design basic and advanced 3D solid Models and surface models of parts using CAD software.	4	Design
CO2	To construct the layer of stl file and applying various priting parametres in Slicer Software and generate its program	4	Construct
CO3	Build the part by printing it on 3d printer	2	Build

CO-PO Mapping:

CO	1	2	3	4	5	6	7	8	9	10	11	12
CO1	√											√
CO2	√								√			√
CO3		√		√		√						√

Assessments :

Assessments :

Teacher Assessment:

One component of In Semester Evaluation (ISE) and one End Semester Examination (ESE) having 50%, and 50% weights respectively.

Assessment	Marks
ISE	50
ESE	50

ISE are based on practical performed/ Quiz/ Mini-Project assigned/ Presentation/ Group Discussion/ Internal oral etc.

ESE: Assessment is based on oral examination

Course Contents:

Unit 1: Generation of Solid/Surface model of industrial component using any commercialy available high end CAD software. Convering the Solid/Surface model into .stl format.	6 **Hrs.**
Unit 2:--- Importing stl file into slicer software like CURA. Applying various 3D printing parameters like nozzle diameter, Nozzle temperature, Bed temperature, Layer thickness, Shell thickness, Top and Bottom layer height, FIll density, Support, Support density etc. GEneration of program to print object on 3D printer.	8 Hrs.
Unit 3:-- Process overviews, Process Strength & limitations, of Fused Deposition Modeling construction and working of 3D Printer available in the lab, Inserting Filament in nozzle	2 Hrs.
Unit 4: Transferring the program to machine and carry out 3D printing on actual machin in the lab. Part cleaning.	8 Hrs.

Textbooks:

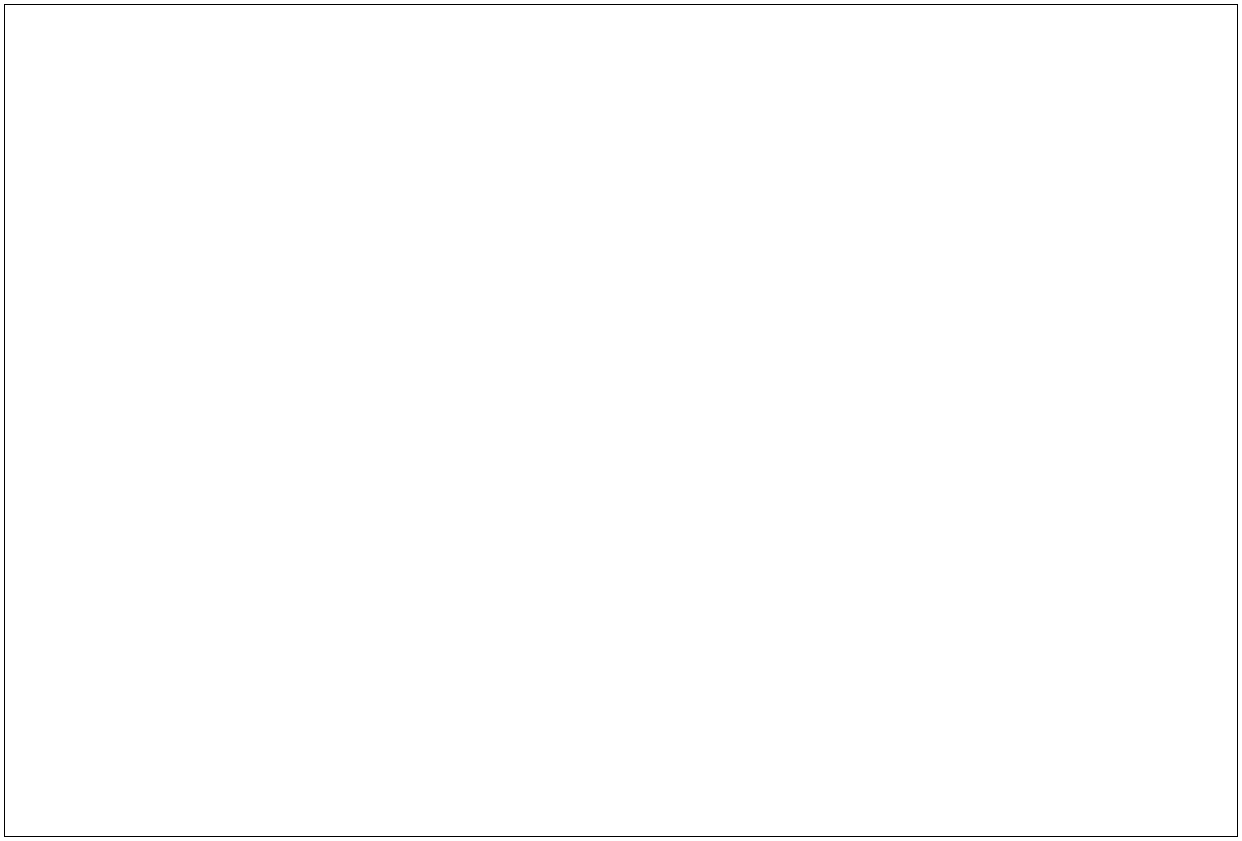
1. Rapid Manufacturing: An Industrial Revolution for the Digital Age – Editors N. Hopkinson, R.J.M. Hague and P.M. Dickens, (2006) John Wiley & Sons, Ltd., ISBN-10 0-470-01613-2 Pereira, J.A. Pérez, J.L. Diéguez, G. Peláez and J.E. Ares,
2. "Design and anufacture of casting pattern plates", by rapid tooling, Archives of Materials Science, Vol. 29, No. 1-2, 2008 63
3. Rafiq Noorani, Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley & Sons, 2006.

References:

1.	Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital
2.	Laser Additive Manufacturing of High-Performance Materials, Dongdong Gu, Springer
3.	Understanding Additive Manufacturing, Andreas Gebhardt, Hanser Publishers, 2011.
4.	Chua Chee Kai., Leong Kah Fai., Chu Sing Lim, Rapid Prototyping: Principles and
5.	Ian Gibson., David W Rosen., Brent Stucker., Additive Manufacturing Technologies:

Unit wise Measurable students Learning Outcomes:

1. Students shall be able to describe the current available Additive Manufacturing systems, their fundamental operating principles, characteristics and limitations.
2. Students shall be able to Distinguish between traditional and Rapid Manufacturing process.
3. Students shall be able to Explain the principles and key characteristics of commonly used processes in additive manufacturing.
4. Students shall be able to Select the appropriate materials and rapid prototyping processes for a given prototyping task
5. Students shall be able to Apply criterion for selecting appropriate additive manufacturing process for any given application in the areas like automotive, aeronautics, tooling and biomechanics etc.
6. Students shall be able to Select appropriate Additive Manufacturing Process in the area of tooling.



Title of the Course: DESIGN OF THERMAL SYSTEMS LAB	L	T	P	Credit
Course Code: PMDN0140	-	-	2	1

Course Pre-Requisite: Applied Thermodynamics, Fluid Mechanics, Heat & Mass Transfer, Refrigeration and Air-conditioning.

Course Description:

This subject enables the student to understand the different components, accessories and controls used in refrigeration systems. The students will be able to understand mathematical formulation of components as well as a whole thermal system. The students will be able to estimate the heat load calculations for refrigeration applications and will be able select or design appropriate components.

Course Objectives:

1. Learn thermal system design methodology.
2. Learn mathematical formulation of components as well as a whole thermal system
3. Learn estimation of heat load calculations for refrigeration applications.
4. Design simple thermal systems.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	Apply knowledge of mathematics, science, and engineering for mathematical formulation of components as well as a whole thermal system.	3	Applying
CO2	Analyze the heat load calculations for refrigeration applications	4	Analyze
CO3	Design the thermal systems.	5	Design

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3												3		
CO2	3	2												2	2
CO3		2		3	3										

Assessments :

Teacher Assessment:

One component of In Semester Evaluation (ISE), and End Semester Examination (ESE) having 50% weightage each.

Assessment	Marks
ISE	50
ESE (P.O.E)	50

ISE is based on experiments/assignments etc.

ESE: Assessment is based on 100% course content based on the experiments performed and included in journal

Course Contents: Any Six Experiments to be Performed out of 10 given below.

EXPT 1: Mathematical formulation of thermal systems [component level and system level]	**2 Hrs**

EXPT 2. Heat load Calculations & Design of water chilling plant	**2 Hrs**
EXPT 3:Heat load Calculations & Design of cold storage plant	**2 Hrs**
EXPT 4:Design of de-super heater coil	**2 Hrs**
EXPT 5: Heat load Calculations & Design of domestic Refrigerator	**2 Hrs**
EXPT 6: Heat load Calculations & Design of refrigerated van.	**2 Hrs**
EXPT 7: Exergy analysis of heat exchanger	**2 Hrs**
EXPT 8: Visit to Central AC System	**2 Hrs**
EXPT 9: Visit to Cold Storage	**2 Hrs**
EXPT 10: Visit to Ice Plant	**2 Hrs**

Textbooks:

1. "Thermal Design & optimization", Adrian Bejan, George Tsatsaronis, Michael Moran, JOHN WILEY & SONS INC .
2. "The Exergy Method of Thermal Plant Analysis", T. J. Kotas, British Library Cataloguing in Publication Data.
3. "Exergy, Energy, Environment and Sustainable Development ", Ibrahim Dincer, Marc A. Rosen
4. "Handbook of Process Heat Transfer", Hewitt

References:

1. "HVAC System Design Handbook" ASHRAE.
2. "Design and Optimisation of Thermal Systems", Yogesh Jalurkar, CRC Press.
3. "Design and Simulation of Thermal Systems", N.V. Suryanarayana, Oner Arici, Tata Mc Graw Hill Inc.
4. "Thermal System Design",Stoecker, Tata McGrew Hill Publication, 3rd Edition.

Title of the Course: Advanced Finite Element Methods Course Code: PMDN0204	L	T	P	Credit
	3	-	-	3

Course Pre-Requisite:

- Fundamentals of Strength of Materials
- Fundamentals of Finite Element Analysis

Course Description:

• Plate and Shell elements
• Instability analysis
• Time-dependent finite element procedure
• Nonlinear finite element procedures
• Error estimate and adaptive refinement

Course Objectives:

1. The objective of this course is to learn advanced topics in Finite Element methods so that this tool can be used for analysis, design, and optimization of engineering systems.
2. Study of error estimation in Numerical solutions

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	Analyse linear, nonlinear and simple time-dependent problems in structural discipline using finite element methods	II	Analyse
CO2	Undertake some projects on large deformation and transient nature	III	Undertake
CO3	Develop some special FEA codes for solving nonlinear problems	IV	Develop
CO4	Estimate the errors in Finite Element Analysis	V	Estimate

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	1		
CO2		2	
CO3			3
CO4			2

1:low, 2: medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30

ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:--- **Integral Formulation and Variation Methods** Introduction to Finite Element Method, comparison with other methods, Discritization of the problem, Need for weighted-integral forms, relevant mathematical concepts and formulate, weak formulation of boundary value problems, variational methods, Rayleigh-Ritz method and weighted residual approach.	6 **Hrs.**
Unit 2:--- **Two-Dimensional Problems: Beam and Truss** Introduction; Local and global coordinate systems; Transformation of vectors in two and three dimensional spaces; Finite Element Modeling of a basic truss element in local coordinate system; Assembly of the Global Stiffness Matrix and Load vector, Finite Element Modeling of beam element, problems on beam and truss	8 **Hrs.**
Unit 3:--- **Applications to Solid and Structural Mechanics Problems** Application of FEM in Stress Analysis-2D Analysis- CST, LST and Quadrilateral Elements Axi-Symmetric analysis- LST and Quadrilateral Elements 3D Analysis- Tetrahedron and hexahedron elements, Isoparametric elements.	8 **Hrs.**
Unit 4:--- **Applications to Heat Transfer Problems** Formulation and solution of 1D and 2D problems, 1D Analysis: conduction, convection and radiation, 2D Analysis: conduction and convection only.	6 **Hrs.**
Unit 5:--- **Non linear and dynamic analysis:** Introduction to Nonlinearity, Sources of Nonlinearity- Material nonlinearity, Geometric nonlinearity, Boundary and Contact Nonlinearity , Small vs Large Displacement Nonlinear Analysis, Bolt Pretension, Gasket Analysis. Applications of FEM in Dynamic analysis, static verses dynamic analysis, Eigen value problem, frequency analysis, Modal analysis, methods of avoiding resonance, transient problems.	8 **Hrs.**
Unit 6:--- **Modeling procedures and results processing:** Model validity and Accuracy, Mesh design and refinement, Element	4 **Hrs.**

distortion, Sources of error, Model checking, results processing and validation**.**	

References:

1] Bathe K.J. Finite Element Procedures. Prentice Hall, 1996.
2] Belytschko, T. et al. Nonlinear Finite Elements for Continuum and Structures, John Wiley & Sons, 2000
3] Cook, R.D. et al. Concepts and Applications of Finite Element Analysis, John Wiley & Sons, 2004.
4] Zienkiewicz, O.C. and Taylor, R.L. The Finite Element Method, Butterworth 5. Heinemann, 2000.

Title of the Course: Analysis and Synthesis of Mechanisms	L	T	P	Credit
Course Code: PMDN0205	3	1	-	4

Course Pre-Requisite: Acquaintance with the basic concepts of Theory of Machines and Dynamics of machines.

Course Description:

Mechanisms and machines are important part of mechanical engineering. The study of mechanism involves their analysis as well as synthesis. Analysis is the study of motions and forces where as synthesis involves design of different parts. The course includes kinematic analysis of mechanism –mainly analytical methods, Synthesis of mechanism- graphical and analytical methods, spatial mechanisms, analysis of robotic arm elements.

Course Objectives:

1. To understand the fundamentals of kinematic and synthesis of machines and Mechanisms.

2. To train the students to apply graphical and analytical methods for analysis/synthesis of Mechanisms.

3. To acquaint students with modern software for kinematic and dynamic analysis of the Mechanisms.

4. To develop students to design mechanisms to solve industrial problems.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Apply the knowledge of synthesis of mechanism to different machines and mechanisms	III	Applying
CO2	Demonstrate skill of using different software for analysis of mechanisms.	III	Applying
CO3	Analyze different types of mechanisms used in practice.	IV	Analyzing
CO4	Design different types of mechanisms to solve industrial problems.	VI	Creating

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	2	2	
CO2	3		2
CO3	2	2	
CO4	3	3	3

1:low, 2: medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:- Kinematics of Mechanism - Review of Basic Concepts; planar and spatial mechanisms; kinematic pairs; degree of freedom; equivalent mechanisms; Loop closure equation, Freudenstein's Equation, Coupler curves for four bar chain and slider crank chain.	6-- **Hrs.**
Unit 2:- Advanced kinematics of plane motion - The inflexion circle - Euler-Savary equation, Bobbileier's construction, Hartman's construction, Application of inflection circle to kinematic analysis, Polode curvature - General case and special case,	6 -- **Hrs.**
Unit 3:- .Introduction to synthesis – Dimensional synthesis of mechanisms, Chebyshov-polynomials, Spacing of accuracy points, guiding a point through two, three and four, distinct positions - Burmaster's curve, Function generation - Overlay's method, Path generation - Robert's theorem.	6 -- **Hrs.**
Unit 4:- Graphical Methods - Geometric Methods of synthesis of planner Mechanisms- Two finitely separated link positions, three separate link positions, poles and relative poles, Synthesis with three accuracy points, four finitely separated link positions, pole triangle, image poles, opposite poles, quadrilateral circle points and center points curves, synthesis with four accuracy point	8 -- **Hrs.**
Unit 5 :- Analytical Methods - Algebra method of synthesis of planer mechanisms – Displacement equations of the four bar linkage, synthesis with three accuracy points , synthesis with prescribed velocity and acceleration, synthesis with four accuracy points, structural error curve, analysis of Mechanical error in linkages.	8 -- **Hrs.**
Unit 6 :- Spatial mechanisms-Synthesis of spatial linkages, displacement analysis, matrix method of analysis, function generator for symmetric function, application of spatial mechanisms to Robotics , kinematics analysis of industrial robots, manipulators , gripper theory , Computer aided analysis of mechanisms and introduction to dynamic analysis mechanisms	8 -- **Hrs.**

Textbooks:

1. J.E. Shigley&J.J.Vickel, "*Theory of Machines and Mechanisms*", International students edition, 2001.

2. J.E. Shigley , "*Kinematic Analysis of Mechanism*", MacGraw Hill, 1969.

3. A. Ghosh and A.K. Mallik, "Theory of Machines and Mechanisms", Affiliated East-West Press, New Delhi, 1988.

References:

1. Wilson C E, Sadler J P, "Kinematics and Dynamics of Machinery*",* HRP, First Edition, 1990.

2. Waldron K J, Kinzel G L, "*Kinematics, Dynamics and Design of Machinery",* Wiley India, First Edition, 2004.

3. Arthur G Erdman and George N. Sander, "Mechanisms Design Analysis and Synthesis Volume
I, II",4th edition, 2001.

4.Hamilton H.Mabie,"Mechanisms and Dynamics of Machinery",John Wiley and sons New York

5.S.B.Tuttle,"Mechanisms for Engineering Design" John Wiley and sons New York

Unit wise Measurable students Learning Outcomes:

1. The student shall be able to develop coupler curves for simple planer mechanisms.
2. The student shall be able to analyze complex mechanisms.
3. The student will learn basics of synthesis.
4. The student shall be able to synthesize mechanism using graphical method.
5. The student shall be able to synthesize mechanism using analytical method.
6. The student shall be able to synthesize spatial mechanisms necessary for robots.

Title of the Course: Advanced Materials Course Code: PMDN0206	L	T	P	Credit
	3	1	-	4

Course Pre-Requisite: B. Tech In Mechanical/Production Engineering.

Course Description:

Advanced materials will provide fundamental knowledge of material science along with advanced materials and their criteria of selection according to applications

Course Objectives:

CO1. To provide fundamental knowledge of Engineering materials
CO2. Study of advanced material viz. smart materials, composites, carbon nanotubes etc.
CO3. Selection of various materials according to applications
CO4. To acquire the knowledge of various characterization techniques

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Students will be able to **select** materials according to its application	1	Remember
CO2	**Make use of** modern instrumental and classical techniques for characterizing materials.	3	Apply
CO3	**Explain** the effects of microstructural parameters on the properties of composite.	5	Evaluate
CO4	Students will be able to process advanced materials like composites, MEMS, biomaterials etc.	6	Create

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1			1
CO2	1		1
CO3		1	2
CO4			3

1:low, 2:medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1: **Review of Engineering Materials**- metals, alloys- ferrous and non-ferrous, plastics and polymers, ceramics and composites. Dual phase steels, micro alloyed steels, High strength low alloy steels, Maraging steels. Heat treatment of ferrous and nonferrous alloys for modification of structure and properties.	**6 Hrs.**
Unit 2: **Modern materials**- Compositions, properties and applications of: Inter-metallics, Ni and Ti aluminides, smart materials, shape memory alloys, Metallic glass- quassi crystals, Dielectrics, semiconductors, conductors & super conducting materials. Magnetic and photoelectric materials, optical materials, micro electronic materials.	**7 Hrs**
Unit 3: **Non Metallic Materials**- Polymers types, Structure, properties and applications of engineering polymers. Polymer matrix composites properties, extrusion and injection moulding, hand layup technique etc. Composites: Fibers-glass, boron, carbon, organic, ceramic and metallic fibers-orientation, size, quantity and associated properties.	7 **Hrs.**
Unit 4: **Selection of Materials**: Motivation for selection, cost basis and service requirements selection for mechanical properties, strength, toughness, fatigue and creep. Selection for surface durability, corrosion and wear resistance. Relationship between materials Selection and processing. Case studies in material selection with reference to aero, automobile, marine, machinery and nuclear applications	6 **Hrs.**
Unit 6: Nano and Bio materials Introduction types of nanomaterials, size, shape, lumen space, surface characteristics-hrdrobhobic/fillic, fire retardancy, synthesis and modification, filling of nanotubes, mechanism of growth, electronic structure, aggregation. nanotubes filled polymer composites properties-thermo-mechanical, physical properties and its applications, nanofluids and its effect on performance measures in machining. Biomaterials, importance, classification, manufacturing technologies and applications of biomaterials in biomedical and instrumentation engineering. Costing of nano and bio materials.	**7 Hrs.**
Unit 6: **Characterization of nanomaterials/composites** Basic concepts, Nano and Nature, Introduction to Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), differential scanning calorimeter (DSC) & thermogravimetric analysis (TGA), X-ray diffraction (XRD) & Fourier Transform Infrared Spectroscopy (FTIR).	**7 Hrs.**

Textbooks:

1. G. K. Narula, K. S. Narula, V. K. Gupta, "Material Science", TMH, 2007
2. Pradeep T, "Nano: The Essentials", McGraw Hill Publishing Co. Ltd., 2007
3. William D. Callister, Jr. "Materials Science and Engineering An Introduction", John Wiley & Sons, Inc.7th Edition
4. "Manufacturing Science" - A. Ghosh and Malik – Affiliated East West Press Pvt. Ltd.
5. Agarwal D & Brontman L.J., "Analysis & Performance of Fibre Composites", John Willey Publications, 1990
6. Mallik P.K. & Newman S., Composite Materials Technology", Henser Publications, 1990

7. Krishnan K. Chawla, “Composite Material Science and Engineering”, Springer- Verlag, 1987
8. “HMT Handbook” – Production Technology (TMH)
9. Microstructural Characterization of Materials - Wayne D. Kaplan, David Brandon
10. Materials Characterization- Antonio Contreras Cuevas, Rodrigo A. Esparza Muñoz
11. Materials Characterization Techniques – 1st Edition-Sam ZhangLin Li, Ashok Kumar CRC Press

References:

1. “Shape memory materials”,Edited By- K. Otsuka and C M Wayman, Cambridge Univ. Press
2. Anke Krueger, “Carbon materials and nano technology”, Wiley – VCH
3. “Shape memory polymers and multifunctional composites” Edited by JinsongLeng and Shanyi Du,
CRC Press.
4. Geoff Eckold “Design & Manufacturing of Composite Structures”, (Jaico Publishing House)
5. Encyclopedia of Materials Characterization: Surfaces, Interfaces, Thin Films- C. R. Brundle, Charles A. Evans, Shaun Wilson

Title of the Course: Process Equipment Design Course Code:PMDN0221	L	T	P	Credit
	3	1	-	4

Course Pre-Requisite:
Knowledge of Machine Design and Analysis of Mechanical Elements

Course Description:
The Process equipment Design course is a focused learning approach to understand the design procedures of special equipments related with processes as per standards

Course Objectives:
Be familiar with various standard practices of designing process equipments

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Identify different types of process equipments as per standards	III	Applying
CO2	Examine requirements of equipment fabrication and testing	IV	Analysing
CO3	Determine parameters for process equipment design	V	Evaluating
CO4	Design Process equipments as per standards	VI	Creating

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	3	-	1
CO2	2	1	1
CO3	2	1	3
CO4	3	1	3

1:low, 2: medium, 3:high

Assessments :

Teacher Assessment:
Two components of In semester Evaluation and one component of Mid semester Evaluation (MSE) and one End semester Evaluation (ESE) having 20%, 30% and 50% weight age respectively.

Assessment	Marks
ISE –I	10
MSE	30
ISE-II	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with 60-70% weight age for course content (normally last three modules) covered after MSE

Course Contents:	
Unit 1. Study of Pressure Vessels- Type of vessels and factors influencing the design of vessels. Classification of vessels such as tank, flat, bottomed and vertical cylinder tank, vertical cylindrical and horizontal vessels with formed ends as well as spherical or modified spherical vessels. Introduction to IS and ASME pressure vessel codes and standards	**6 Hrs**
Unit 2. Design Considerations of pressure vessels Criteria in vessel design. Elastic bending, plastic instability, cyclic loading stress reversals. Brittle rupture and creep rupture corrosion, Design of simple vessels of different configuration. General proportions and lay-out. Vents, tapping and flanges	**6 Hrs**
Unit 3: Pressure vessel supports Different types of pressure vessel supports, types of tall vertical vessels, Design considerations of pressure vessel supports	**6 Hrs**
Unit 4: study of Heat Exchangers : Introduction, Scope of shell-and-tube heat exchanger, Components of shell and tube heat exchangers (shell, shell cover, tubes, tube sheet, baffles and nozzles), Construction, TEMA standards, TEMA terminology, ASME codes Sec VIII Div 1, and WRC 107	**8 Hrs**
Unit 5: Mechanical design of Heat Exchangers : Introduction to Tinker's, Kern's, and Bell Delaware's methods, for thermal and hydraulic design of Shell and Tube heat exchangers.Design standards and codes, Key terms in heat exchanger design and thickness calculation for major components such as tube sheet, shell and tubes	**6 Hrs**
Unit 6: Mechanical design of Storage tank: Mechanical design of Storage Tank Classification of storage tank as per IS-803, Capacity of storage tank, its diameter & height, Design of shell and bottom plate for storage tank, Design of Self supported conical roof, Design of structured supported conical roof as per API 620, Selection of column, girders and rafters, Roof curb angel, Floating roof	**6 Hrs**

Reference Books:

1. Process Equipment Design, M.V. Joshi, V. V. Mahajani, Macmillan India

2. Pressure vessels design and practice, Somnath Chattopadhyay

3. Overview of pressure vessel design, By: Vincent A. Carucci. Publication: ASME International

4. Process equipment design, Brownell and Young. Publication: Wiley Eastern Limited. Ed:1959, sixth reprint Sept 1991.

5. ASME Section VIII Div-1, 2 & 3 Ed. 2010 Addenda 2011a.

6. Theory & Design of Pressure Vessels, By: John F Harvey, 15th Edition, Van Nostrand Reinhold Company Ltd.

7. Pressure Vessel Design Handbook‖ By H. Bedner

8. Pressure Vessel Design Manual – Dennis Moss
9. "Introduction to Process Engineering and Design" by S B Thakore and B I Bhatt, Tata McGraw Hill, 1st Edition, 2007

10. R. K. Sinnott, Coulson & Richardson's Chemical Engineering: Chemical Engineering Design (volume 6), Butterworth-Heinemann, 3rd ed. 1999

Title of the Course: Design of Material Handling Equipment Course Code: PMDN0222	L	T	P	Credit
	3	1	-	4

Course Pre-Requisite:
Machine Deign, Theory of Machine, Metallurgy.

Course Description:
The focus of Design of Material Handling Equipment is to develop an understanding the material handling facilities and the fundamental principles of material handling. Also some basic design consideration like conveyor, belt, pulley etc. This course will be also introducing design of hoisting element brakes, shoes, band break, hooks. Also covers the safety issues and regulations in material handling.

Course Objectives:

1. To understanding of material handling facilities and the fundamental principles of material handling.
2. To understand the techniques for designing material handling systems and their limitations.
3. To understanding of safety issues and regulations in material handling.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Identify the safety issues and applications of optimization techniques to material handling.	I	Knowledge
CO2	Apply appropriate techniques for improving existing material handling systems.	III	Application
CO3	Select appropriate equipment for material handling and understand the basic roles of the different equipment.	IV	Analysis

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	2	3	
CO2		3	1
CO3	3	2	

1:low, 2:medium, 3:high

Assessments :
Teacher Assessment:
Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	
MSE	

ISE 2	
ESE	

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:Elements of Material Handling System Introduction, Importance, Terminology, Objectives and benefits of better Material Handling; Principles and features of Material Handling System; Interrelationships between material handling and plant layout, physical facilities and other organizational functions; Classification of Material Handling Equipment.	5 **Hrs.**
Unit 2: Selection of Material Handling Equipment Factors affecting for selection; Material Handling Equation; Choices of Material Handling Equipment; General analysis Procedures; Basic Analytical techniques; The unit load concept; Selection of suitable types of systems for applications ; Activity cost data and economic analysis for design of components of Material Handling Systems; functions and parameters affecting service; packing and storage of materials.	6 **Hrs.**
Unit 3:Conveyor Design Introduction on Conveyor Design, apron conveyors, Pneumatic conveyors, Belt Conveyors, Screw conveyors and vibratory conveyors and their applications, Design of Belt conveyor-Belt selection procedure and calculation of drop energy, Idler design.	8 **Hrs.**
Unit 4:Design of hoisting elements Introduction, Welded and roller chains, Hemp and wire ropes, Design of ropes, pulleys, pulley systems, sprockets and drums, Load handling attachments. Design of forged hooks and eye hooks crane grabs-lifting magnets, Grabbing attachments, Design of arresting gears, Brakes, shoe, band and cone types.	8 **Hrs.**
Unit 5:Design of cranes Introduction, Hand-propelled and electrically driven E.O.T overhead Traveling cranes; Traveling mechanisms of cantilever and monorail cranes; design considerations for structures of rotary cranes with fixed radius ; fixed post and overhead traveling cranes; Stability of stationary rotary and traveling rotary cranes.	8 **Hrs.**

Unit 6: Design of Bucket Elevators	5 **Hrs.**
Introduction, Types of Bucket Elevator, Design of Bucket Elevator loading and bucket arrangements, Cage elevators, shaft way, guides, counter weights.	

Textbooks:

1. Conveyor Equipment Manufacturer' s Association, " Belt conveyors for bulk materials" 6th edition, The New CEMA Book
2. Rudenko N., " Materials handling equipment " , Elnvee Publishers, 1970
3. Ishwar G Mulani and Mrs.Madhu I Mulani, " Engineering Science and application design for belt conveyor" , Madhu I. Mulani, 2002.

References:

1. Spivakovsy A.O. and Dyachkov V.K., " Conveying Machines, Volumes I and II", MIR Publishers, 1985.
2. Alexandrov, M., " Materials Handling Equipments " , MIR Publishers, 1981.

Unit wise Measurable students Learning Outcomes:

1. **Explain the importance of material handling system and plant layout.**
2. **Explain the selection material equipment for suitable application.**
3. **Design the conveyor and select belt for mechanical system.**
4. **Apply the knowledge for designing hoisting element.**
5. **Create the mechanisms for cantilever and monorail cranes.**
6. **Design the material handling system for lifting purpose.**

Title of the Course: Optimization Techniques in Mechanical Engineering Course Code: PMDN0223	L	T	P	Credit
	3	1	-	4

Course Pre-Requisite: Nil

Course Description: This course covers classification of optimization problems, techniques to solve classical, single variable and multi variable optimization problems. It describes steps in carrying out experiment using taguchi method. Course contains Modern Approaches in Optimization Techniques.

Course Objectives:

1. To introduce to various optimization techniques.
2. To use suitable optimization technique to solve practical problems.
3. To make use of Taguchi method to carry out various experiments.
4. To study Modern Approaches in Optimization Techniques

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	Describe different methods of optimization	II	Understanding
CO2	Develop a mathematical model for a given problem	III	Applying
CO3	Solve practical problems using suitable optimization technique	IV	Analyzing
CO4	Explain Modern Approaches in Optimization Techniques	II	Understanding

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	2		
CO2			2
CO3			2
CO4	2		

1:low,2:medium,3:high

Assessments : Teacher

Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc. MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with 60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:--- Introduction to optimization Techniques Introduction to optimization techniques, Statement of an optimization problem: Design vector, Design constraints, Constraint surface, objective function, objective function surfaces, Classification of optimization problems: classification based on the existence of constraints, nature of design variables, physical structure of the problem, nature of equations involved, permissible values of design variables, deterministic nature of variables, separability of the functions, number of objective functions Engineering applications of optimisation, Engineering applications of optimization.	**6 hrs**
Unit 2:--- Classical Optimization Techniques: Single-variable and Multi-variable Optimization, Hessian Matrix, Saddle Point, Lagrange Multipliers Method and Kuhn-Tucker Conditions	**6 hrs**
Unit 3:--- Single-variable Optimization Techniques Linear and Non-Linear behavior, Unrestricted Search, Solution using Graphical Method and Numerical Methods, Interval-halving Method, Goldensection Method, Newton Method, Secant Method	**8 hrs**
Unit 4:--- Multi-variable Optimization Techniques Non-linear Equations, Steepest Descent Method, Conjugate Gradient Method, Davidson-Fletcher-Powell Method	**8 hrs**
Unit 5:--- Taguchi Method Introduction, Loss Function and Signal –to-noise ratios, Control Factors and Noise Factors, Orthogonal Design, Design of Experiments, steps in carrying out experiment, analysis of variances etc.	**6hrs**
Unit 6:-- Modern Approaches in Optimization Techniques Genetic algorithms, Simulated Annealing, Particle Swarm Optimization, Ant Colony Optimization, Teaching Learning Based Optimization, Introduction to ANN	**6 hrs**

Textbooks:

1. Singiresu S. Rao Engineering Optimization: Theory and Practice, John Wiley & Sons
2. Belegundu, Chandrupatla, Optimization concepts and applications in Engineering, Pearson Education
3. Adler and Granovky, Optimization of Engineering Experiments, Meer Publications
4. C.R. Kothari, “Research Methodology”, Wiley Eastern Publication.

References books:

1. Trochim, William M.K. (2003), 2/e, Research Methods, (Biztantra, Dreamtech Press, New Delhi), ISBN : 81-7722-372-0
2. Montgomery, Douglas C., & Tunger, George C. (2007). 3/e, Applied Statistics & Probability for Engineers, (Wiley India).
3. Ross P.J., “Taguchi Techniques for Quality Engineering”, TMH, 2005.
4. Jeff Wu, “Experiments: Planning, Analysis and Parameter Design”, John Wiley, 2000.
5. Fox R.L., “Optimization Methods for Engineering Design”, Addison Wesley, 1971.

Title of the Course: Micro and Nano System Design Course Code: PMDN0224	L	T	P	Credit
	3	1	-	4

Course Pre-Requisite: Engineering Physics, Engineering Chemistry

Course Description:3

- Have a concept on the scope and recent development of the science and technology of micro and nano systems.
- Gain the physical knowledge underlying the operation principles and design of micro and nano systems.
- Learn some typical or potentially applicable micro and nano systems at the frontier of the development of the field.

Course Objectives:

1. Ability to understand the operation of micro devices, micro systems and their applications.
2. Ability to design the micro devices, micro systems using the MEMS fabrication process.
3. Gain knowledge of basic approaches for various sensor designs.
4. Gain knowledge of basic approaches for various actuator designs.
5. Develop experience on micro/nano systems.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Acquire the knowledge of micro devices, micro systems and their applications	I	Knowledge
CO2	Select the material for micro and nano components	IV	Analysis
CO3	Design the micro devices, micro systems using the MEMS fabrication process.	V	Synthesis
CO4	Develop experience on micro or nano systems	III	Application

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	1		
CO2	1		
CO3	1	2	2
CO4	2	2	3

1: low, 2:medium, 3:high

Assessments : **Teacher Assessment:**	
Course Contents:	
Unit 1:--- OVERVIEW AND INTRODUCTION New trends in Engineering and Science: Micro and Nano scale systems Introduction to Design of MEMS and NEMS, Overview of Nano and Micro electromechanical Systems, Applications of Micro and Nano electro mechanical systems, Micro electromechanical systems, devices and structures Definitions,	**6 Hrs.**
Unit 2:--- MATERIALS FOR MEMS Introduction - substrates and wafer- silicon substrate - crystal structure, miller indices, properties - silicon compounds - silicon dioxide, silicon carbide, silicon nitride, polycrystalline silicon- gallium arsenide - quartz- piezoelectric crystals -polymers - polymers for MEMS, conductive polymers.	**6 Hrs.**
Unit 3:--- MEMS FABRICATION TECHNOLOGIES Microsystems fabrication processes: Photolithography, Ion Implantation, Diffusion, Oxidation. Thin film depositions: LPCVD, Sputtering, Evaporation, Electroplating; Etching techniques: Dry and wet etching, electrochemical etching; Micromachining: Bulk Micromachining, Surface Micromachining, High Aspect-Ratio (LIGA and LIGA-like) Technology; Packaging: Microsystems packaging, Essential packaging technologies, Selection of packaging materials.	**8 Hrs.**
Unit 4:--- MICRO SENSORS MEMS Sensors: Design of Acoustic wave sensors, resonant sensor, Vibratory gyroscope, Capacitive and Piezo Resistive Pressure sensors- engineering mechanics behind these Microsensors.	**6 Hrs.**
Unit 5:--- MICRO ACTUATORS Design of Actuators: Actuation using thermal forces, Actuation using shape memory Alloys, Actuation using piezoelectric crystals, Actuation using Electrostatic forces (Parallel plate, Torsion bar, Comb drive actuators),	**6 Hrs.**

Micromechanical Motors and pumps.	
Unit 6:--- NANOSYSTEMS AND QUANTUM MECHANICS Atomic Structures and Quantum Mechanics, Molecular and Nanostructure Dynamics: Shrodinger Equation and Wavefunction Theory, Density Functional Theory, Nanostructures and Molecular Dynamics, Electromagnetic Fields and their quantization, Molecular Wires and Molecular Circuits.	**8 Hrs.**
Textbooks: 1. Marc Madou, "Fundamentals of Micro fabrication", CRC press 1997. 2.Stephen D. Senturia," Micro system Design", Kluwer Academic Publishers,2001	
References: 1. Tai Ran Hsu ,"MEMS and Microsystems Design and Manufacture" ,Tata Mcraw Hill, 2002. 2. Chang Liu, "Foundations of MEMS", Pearson education India limited, 2006	

Title of the Course: Design for Fatigue	L	T	P	Credit
Course Code: PMDN0225	3	1	-	4

Course Pre-Requisite:

- Applied Science
- Material Science

Course Description:

This course deal with fundamental and technical issues associated with designing and maintaining structures that resists failure from cyclic loading. Students will be taught the principles of analyzing the failure of materials by fatigue including how fatigue behaviour is characterized, how fatigue failure is predicted, and the physical mechanisms responsible for fatigue failure of various materials with particular attention to metals and structural alloys, and how such behaviour is related to the microstructure of the material.

Course Objectives:

- To evaluate the fatigue of structure.
- To determine the strength of cracked bodies.
- To know the concepts and principles of various failures in materials.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Comprehend the mechanism of fatigue in various materials and importance of fatigue testing methods in engineering applications	V	Evaluating
CO2	Explain the stress and strain based models of fatigue life estimation	II	Understanding
CO3	Predict the mechanism of fatigue crack growth and analyze the effect of fatigue loading under variable amplitude and the effects of environment.	VI	Creating
CO4	Explain the various theories of multi-axial fatigue and the impact of residual stresses	V	Evaluating

CO-PO Mapping:

CO	1	2	3
CO1	2		
CO2		1	
CO3			3
CO4			2

1:low, 2: medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:- **Fatigue of Materials:** Introduction & Historical overview, Modes of mechanical failures- Static & Fatigue, Fatigue design Philosophies & Life estimation model, Macro and Micro aspects of fatigue, Review of theories of failures for ductile & brittle materials, Fatigue of ferrous & non-ferrous materials, Composites, plastics & ceramics, High cycle & Low cycle fatigue, Standard fatigue testing procedures	**07 Hrs.**
Unit 2:- **Stress – Life (S-N) Approach:** S–N Curves, Mean stress effects on S-N behaviour, factors approach. S-N approach for notched members, influencing S-N behaviour, Factors influencing S-N behaviour, Life estimation using S-N. **Strain – Life (ε–N) Approach:** Material behaviour,Strain based (ε-N) approach to life estimation, Determination of ε-N fatigue properties, Mean stress effects, Factors influencing ε-N behaviour, Life estimation using ε-N approach	**08 Hrs.**
Unit 3:- **Crack initiation and Propagation:** Crack tip plastic zone, fatigue-crack initiation, crack propagation under constant amplitude, variable amplitude loading, Stress corrosion cracking, corrosion fatigue.	**05 Hrs.**
Unit 4:- **Fatigue From Variable Amplitude Loading:** Fatigue Damage, Spectrum loads, Cumulative fatigue damage, Theories of cumulative fatigue damage, Load interaction and sequence effects, Cycle counting methods, Life estimation using stress life and strain life approach, Crack growth and Life estimation models.	**08 Hrs.**
Unit 5:- **Statistical Analysis of Fatigue Test Data & Fatigue Reliability:** Definitions and Quantification of data scatter, Population and Sampling distributions,	**07 Hrs.**

Normal, Log normal & Weibull distributions, Statistical Hypothesis, Confidence and Tolerance limits, Regression analysis, Reliability analysis.	
Unit 6:- **Multi axial Fatigue :** Introduction, Stress state, cracking observations, Multi-axial theories– Equivalent stress-strain approach, Sine's model, maximum range of shear stress criterion, Equivalent strain range criterion, Critical plane approaches	**05 Hrs.**

Textbooks:

- Metal Fatigue in Engineering, Ralph I. Stephens, Ali Fatemi, Robert .R. Stephens, Henry Fuchs, John Wiley New York, Second edition. 2001.
- Fundamentals of Metal Fatigue Analysis, Julie.A. Benantine Prentice Hall, 1990
- Failure of Materials in Mechanical Design, Jack.A. Collins, JohnWiley, Newyork1992.
- Machine Design, Robert L. Norton, Pearson.

References:

1] Fatigue and Fracture, ASM Hand Book, Volume 19, 2002.
2] Fatigue of Materials, S. Suresh, Cambridge University Press, Cambridge, UK, 2006

Unit wise Measurable students Learning Outcomes:

- **The student shall be able to know the fatigue structure**
- **The student shall be able to understand stress - strain behaviour with respect to fatigue**
- **The student shall be able to understand crack propogation**
- **The student shall be able to understand the concept fatigue from variable amplitude loading**
- **The student shall be able to understand fatigue reliability**
- **The student shall be able to understand the concept of multi axial fatigue**

Title of the Course: Advanced Machine Tool Design	L	T	P	Credit
Course Code: PMDN0226	3	1	0	4

Course Pre-Requisite: Advanced Machine Design

Course Description: This subject enables the student to understand the important concepts of stress and strain, their significance in concept with engineering applications and is useful while studying the
Subjects like, Kinematics of Machines, Theory of machines, Dynamics of Machines.

Course Objectives:

1. To teach the design concepts of the various sections and sub sections of the machine tools.
2. To teach the kinematic systems involved and design of the same.
3. To teach the various methods of machine tool controls.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	Carrying out the basic need analysis of machine tool component design	3	Applying
CO2	Compare different types of Controls of the machine tools	4	Analyzing
CO3	Design the gear boxes for stepped drives	6	Creating

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	3	2	
CO2	2	3	
CO3	3	2	3

1:low, 2:medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1: Classification and Kinematics of Machine Tools:	6 Hrs.

Classification of machine tools on their method of operation, precision of working and rate of production etc., Consideration and trends of design of machine tools, Classification of Kinematic systems used for motion of various elements of machine tools. Kinematic chains for feed motion of various elements of machine tools. .	
Unit 2:Kinematics of Machine Tools: Design consideration for accuracy and precision working, Selection of cutting speed and speed range, method of speed regulation, stepped, step-less drives, Mechanical, Electrical and Hydraulic methods of speed regulation and their comparison. Step-Less Speed Drives: Classification and different methods and their comparison. Working Principles of step-less drives	**7 Hrs.**
Module 3: Stepped drives of machine tools: Gear drive, gear box design, graphical representation of gear box operation with ray diagram, structure diagram and deviation diagram. Gear Teeth Calculations.	**8 Hrs.**
Module 4:Design Considerations for components: Considerations used in design for strength, rigidity - static and dynamic stiffness and life of various elements of machine tools such as bed and frames, slides and tables, spindles and screws etc., Various types of spindles, spindle support, friction and antifriction slide ways used in hydrostatic and aerostatic ways. Hydro and aerostatic bearing. Friction and Antifriction screws.	**6 Hrs.**
Module 5:Controls and Automation; Various control introduced on machine tools and their importance, various systems such as mechanical, electrical, electronic, optical, pneumatic, and hydraulic. Systems used for position control, Their relative merits and demerits, Their application in automation, economics for automation, various stages of automation.	**7 Hrs.**
Module 6: Numerical Control : N.C. system for drives, feed- back device, counting devices, programming of N.C. machines tools, its concept and types. Manual programming, post processor, adaptive control of machine tool, its concept and types, Trends and developments in machine tool design. Design consideration of Special Purpose Machine and Specific Purpose Machines	**6 Hrs.**
References: **Textbooks:** 1. N. K. Mehta "*Machine Tool Design*", Tata M McGraw-Hill Publishing Co. New	

Delhi, 2001.
2. S.K. Basu. *"Machine Tool Design",* Allied Publishing house, 2002
3. M Acherkan, *"Machine Tool Design",* MIR, 2005.

References:

1. F. Koenigsberger, *"Design Principal of Metal Cutting Machine Tool",* McMillan, 1999
2. V. Tergan, *"Fundamental of Industrial Automation",* MIR,2005
3. YoramKoren,*"Numerical Control of Machine Tools",* KhannaPublishing,2000.

Unit wise Measurable students Learning Outcomes:

Students should be able to

1. **Decide the requirements of the machine tool as regards the kinematic accuracy, static and dynamic stiffness etc.**
2. **Decide the various parameters required for metal cutting machine tool as regards the economic cutting speeds, forces on the tools etc.**
3. **Implement the knowledge of advanced gear box design to undertake the development of the gear box.**
4. **Design independently some simple components of machine tools.**
5. **Carry out the multidisciplinary tasks/projects involving the design of machine tool and the computer control of the same.**
6. **Carry out experiments on NC machines and design the process of working with NC machines**

Tutorials :

1. Structures of Machine tools [Visit to Machine shop]
2. Design of Machine Tool Gearbox.
3. Design of Sideways and Guide ways.
4. Design of Spindle.
5. Machine tool controls and automation
6. Composite assignment based on syllabus [Design of SPM].

Title of the Course: COMPUTATIONAL FLUID DYNAMICS Course Code: PMDN0227	L	T	P	C
	3	1	-	4

Course Pre-Requisite: Fluid Mechanics, Heat Transfer, Elementary Numerical Analysis, Ordinary Differential Equation, Partial Differential Equation

Course Description:

Computational fluid dynamics (**CFD**) is a branch of fluid mechanics that uses numerical analysis and data structures to solve and analyze problems that involve fluid flows. Computers are used to perform the calculations required to simulate the interaction of liquids and gases with surfaces defined by boundary conditions

Course Objectives:

Equip students with the knowledge base essential for application of computational fluid dynamics to engineering flow problems.

2. Provide the essential numerical background for solving the partial differential equations governing the fluid flow.

3. Develop students' skills of using a commercial software package

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Build flow problem properly within CFD context.	III	Applying
CO2	Take part in solid modeling and meshing.	IV	Analyzing
CO3	Assess the CFD results by comparing with available data, and discuss the findings.	V	Evaluating

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	3		
CO2	3	2	
CO3			3

1:low, 2:medium,3: high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:	
UNIT 1: **Introduction to Computational Fluid Dynamics :** Computational Fluid Dynamics: What, When, and Why?, CFD Applications, Numerical vs Analytical vs Experimental, Modeling vs Experimentation. **Principles of Conservation:** Reynolds transport theorem, Conservation of mass, Conservation of linear momentum: Navier-Stokes equation, Conservation of Energy, General scalar transport equation. **Classification of Partial Differential Equations and Physical Behaviour:** Mathematical classification of Partial Differential Equation, Illustrative examples of elliptic, parabolic and hyperbolic equations, Physical examples of elliptic, parabolic and hyperbolic partial differential equations	07 **Hrs.**
UNIT 2: **Approximate Solutions of Differential Equations:** Error Minimization Principles, Functional involving higher order derivatives, Approximate solution of differential equations through variational formulation, Boundary conditions in the variational form: Primary and secondary variables, Essential and natural boundary conditions, Approximate solutions of differential equations, Properties of variational form, Weighted residual approach: trial function and weighting function, Requirement of trial function and weighting function, Least square method, Point Collocation method, Galerkin's method, Rayleigh-Ritz method	07 **Hrs.**
UNIT 3: **Fundamentals of Discretisation:** Pre-processing, Solution, Post-processing, Finite Element Method, Finite difference method, Well posed boundary value problem, Possible types of boundary conditions, Conservativeness, Boundedness, Transportiveness, **Finite Volume Method:** Some Conceptual Basics and Illustrations through 1-D Steady State Diffusion Problems: FV Discretisation of a 1-D steady state diffusion type problem, Implementation of boundary conditions	06 **Hrs.**
UNIT 4: **Discretisation of Unsteady State Problems:** 1-D unsteady state diffusion problems: implicit, fully explicit and Crank-Nicholson scheme**.** Consequences of time-discretisation in finite discretisation, Consistency, Stability, Convergence, Stability analysis of parabolic equations (1-D unsteady state diffusion problems), Stability analysis of parabolic equations (1-D unsteady state diffusion problems), Stability analysis of hyperbolic equations: **Solution of Systems of Linear Algebraic Equations:** Criteria for unique solution, infinite number of solutions and no solution, Solution techniques for systems of linear algebraic equations, Generalized analysis of the iterative methods, Sufficient condition for convergence, Rate of convergence, Relaxation methods, Gradient search methods: Steepest descent method and Conjugate gradient method	08 **Hrs.**
UNIT 5: **Discretisation of Convection-Diffusion Equations:** A Finite Volume Approach: Finite volume discretisation of convection-diffusion problem: Generalized convection-diffusion formulation, **Discretisation of Navier Stokes Equations:** Discretisation of the Momentum Equation: SIMPLE Algorithm, SIMPLER Algorithm **Unstructured Grid Formulation:** Discretisation of the Momentum Equation using unstructured grid	06 **Hrs.**

UNIT 6: **What is there in implementing a CFD code?:** The basic structure of a CFD code: Pre-processor, Solver and Post-processor, User-defined-subroutines, Solution to some basic problems in heat transfer and fluid flow. **Introduction to Turbulence Modeling:** Important features of turbulent flow, Vorticity transport equation, Statistical representation of turbulent flows: Homogeneous turbulence and isotropic turbulence, General Properties of turbulent quantities, Reynolds average Navier stokes (RANS) equation, Closure problem in turbulence: Necessity of turbulence modeling, Different types of turbulence model: Eddy viscosity models, Mixing length model, Turbulent kinetic energy and dissipation, The κ-ε model, Advantages and disadvantages of κ-ε model, More two-equation models: RNG κ-ε model and κ-ω model, Reynolds stress model (RSM),Large eddy Simulation (LES),Direct numerical simulation (DNS)	06**Hrs.**

Textbooks:

1. H. K. Versteeg & W. Malalasekera, An Introduction to Computational Fluid Dynamics, Longman Scientific & Technical.
2. John D. Anderson Jr., Computational Fluid Dynamics, McGraw Hill Book Company.
3. J. Blazek, Computational Fluid Dynamics: Principles and Applications, Elsevier.

References:

1. S. V. Patankar, Numerical Heat Transfer and Fluid Flow, McGraw-Hill.
2. T. J. Chung, Computational Fluid Dynamics, Cambridge University Press.
3. J. H. Ferziger and M. Peric, Computational Methods for Fluid Dynamics, Springer.
4. John C. Tannehill, Dale A. Anderson and Richard H. Pletcher, Computational Fluid Mechanics and Heat Transfer, Taylor & Francis.

Unit wise Measurable students Learning Outcomes:

1. Post Graduates will be able to formulate equations of computational fluid dynamics.
2. Post Graduates will be able to solve differential equations of computational fluid dynamics.
3. Post Graduates will be able to discretise the computational fluid dynamics problem
4. Post Graduates will be able to discretise the Unsteady State Problems.
5. Post Graduates will be able to discretise Convection-Diffusion Equations and Navier Stokes Equations
6. Post Graduates will be able to explain the fundamentals of Turbulence Modeling

Title of the Course: Industrial Automation and Robotics	L	T	P	Credit
Course Code: PMDN0228	3	1	-	4

Course Pre-Requisite: Manufacturing Processes, Basic electronics & electrical, Basic Sciences

Course Description: This course gives knowledge about the automation and Robotics. It also describes the emerging trends in Automation and robotics

Course Objectives

1. To understand basic terminologies and concepts associated with Robotics and
2. Automation
3. To study various Robotic sub-systems and Automation systems
4. To study kinematics and dynamics to understand exact working pattern of robots
5. To study the associated recent updates in Robotics and Automation

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	**Apply** knowledge of automation tools and other Equipments by taking into account the fundamental principles manufacturing processes and assembly components.	I	Cognitive (Knowledge)
CO2	To **Apply** knowledge and identify parameters of designing different grippers for various operations.	I	Cognitive (Knowledge)
CO3	To **Acquire** knowledge various Transformations	I	Cognitive (Knowledge)
CO4	To **Analyzing** the problem logically and demonstrate ,& apply knowledge for various forward and backward kinematics behind robots	II	Psychomotor (Skill)

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	2	3	
CO2			2
CO3			2
CO4	2	3	

1:low,2:medium,3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10

MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:- Introduction: Automated manufacturing systems, fixed /programmable /flexible automation, need; Basic elements of automated systems- power, program and control; Advanced automation functions, Levels of automation; Industrial control systems in process and discrete manufacturing industries, Continuous and discrete control; Low cost automation, Economic and social aspects of automation.	**(05)Hrs.**
Unit 2:- Fundamentals of Industrial Robots and Control System: Specifications and Characteristics, Basic components, configurations, Criteria for selection, various industrial applications. Drives, Robot Motions, Actuators, Power transmission systems; Robot controllers, Dynamic properties of robots-stability, control resolution, spatial resolution, accuracy, repeatability, compliance	**(05)Hrs.**
Unit 3:- Spatial Description and Transformations Introduction, Description, Positions orientations and Frames ,Mappings Changing descriptions frame to frame, Operators:-Translations Rotations and Transformations Summary of Interpretations	**(06)Hrs.**
Unit 4:- Manipulator kinematics:- Introduction, link description, link-connection description, convention for affixing frames to links manipulator kinematics, actuator space, joint space, and Cartesian space examples: kinematics of two industrial robots frames with standard names(Numerical Treatment on Forward and Backward Kinematics)	**(06) Hrs.**
Unit 5:- Trajectory generation:- Introduction, general considerations in path description and generation, joint-space schemes, Cartesian-space schemes, geometric problems with Cartesian paths, path generation at run time	**(05) Hrs.**
Unit 6:- Robot Programming: Lead through method, Robot program as a path in space, Methods of defining positions in space, Motion interpolation, branching; Textual robot programming languages	**(04) Hrs.**

Textbooks:

• John J. Craig, Introduction to Robotics (Mechanics and Control), Addison-Wesley, 2nd Edition, 2004
• Mikell P. Groover et. Al., Industrial Robotics: Technology, Programming and Applications, McGraw – Hill International, 1986.
• Shimon Y. Nof , Handbook of Industrial Robotics , John Wiley Co, 2001.
• Automation, Production Systems and Computer Integrated Manufacturing, M.P. Groover, Pearson Education.
• Industrial Automation: W.P. David, John Wiley and Sons.

References:

• Richard D. Klafter , Thomas A. Chemielewski, Michael Negin, Robotic Engineering : An Integrated Approach , Prentice Hall India, 2002.
• Handbook of design, manufacturing & Automation: R.C. Dorf, John Wiley and Sons.

Unit wise Measurable students Learning Outcomes:

UO1.1: Understand the problem and Apply knowledge of automation to simplify and automate the process

UO2.1 Understand and apply the basics fundamentals of gripper selection and design for process under consideration

UO 3.1 Understand and apply the basics fundamentals of drives for different application for different conditions

UO4.1: Students can study the different design considerations of robot with respect to different kinematic aspect and apply knowledge of D-H parameters.

UO5.1: Understand and apply the programming language

UO6.1: Students can study of various aspects Modeling and simulation for optimize the problem under consideration

Title of the Course: Aesthetic & Ergonomic Design	L	T	P	Credit
Course Code: PMDN0229	3	1	-	4

Course Pre-Requisite:

1. Knowledge of machine design, machine tools & analysis of mechanical elements.
2. Basic knowledge of statistics; means, standard deviations, and percentiles
3. Basic Knowledge of measuring equipments

Course Description: An introduction to ergonomics affording students the necessary knowledge essential for the psychological and anthropometrical development leading to good design. To introduce the concepts of man machine systems and techniques of providing human comfort in man-making work systems. Emphasis is placed on health and safety

Course Objectives:

1. Learn the anatomical and mechanical structure of the human body and anthropometry techniques available to engineers,
2. Measure the work content in jobs, tasks, workstations, work environment, and work systems, and how to design,
3. Accurately recognize and evaluate hazards (ergonomic in nature) which are likely to cause occupational illnesses or injuries.
4. Design and redesign tasks and workstations to fit employees.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	To understand the aesthetic and ergonomic consideration in Design	II	Knowledge
CO2	Measure the work content in jobs, tasks, workstations, work environment, and work systems, and how to design,	II	Understanding
CO3	Make practical recommendations and justifications for project solutions.	IV	Analyzing
CO4	Design and/or Redesign of workstations using ergonomically knowledge.	V	Evaluating

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	3	2	1
CO2	2	2	
CO3	1	2	2
CO4	2	1	2

1:low, 2:medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1: Aesthetic and Ergonomic consideration in Design **Introduction:** The evolution of Ergonomics, reasons to use ergonomics, micro- and macro-ergonomics, performing ergonomics, judging the effectiveness of ergonomics intervention. **Ergonomic considerations:** Relation between man, machine and environmental factors. Concept of unity- concept of order with variety -concept of purpose style and environment. **Aesthetic expressions:** Style-components of style- house style, observation style in capital goods, case study.	06 **Hrs.**
Unit 2:--- Human physical dimension concern Human body- structure and function, anthropometrics, Anthropometry: body growth and somatotypes. Static and dynamic anthropometry,Stand Posture- erect. Anthropometry landmark: Sitting postures. Anthropometry: squatting and cross-legged postures. Anthropometric measuring techniques. tatistical treatment of data and percentile calculations. Effect of stresses imposed on body.	8 **Hrs.**
Unit 3:--- Introduction to the concept of system design Analysis of MME system design, How to assess the interface design, Design methodology, Body dimensions and its application in design, Dimensional optimization for the population and use of percentile, The musculo-skeletal system and joint motion study, Human body follows the principle of lever, Basic model on calculation of biomechanical stresses on our body.	8 **Hrs.**
Unit 4:--- Biomechanics in Design Design from the view point of biomechanics, Work posture analysis, Static and Dynamic work, The visual, auditory and thermal environment and their impact on design. Design for the physically challenged	7 **Hrs.**
Unit 5 Product Interface Design Investigations and study of visual, functional and ergonomic requirements of control and display interfaces. Legibility of display elements, character of different typefaces and their readability. Ergonomics of human energy expenditure and its application.	6 **Hrs.**
Unit 6 Methods, Standards and Work Design Determination of work content, workstation, work methods, and times required for various occupational jobs/tasks. Design of tasks/jobs, workplace, and work environment to increase productivity, eliminate waste, and decrease occupational injury/illness.	7 **Hrs.**

Textbooks:

1. Konz SA & Johnson S. Work Design: Industrial Ergonomics. 6th Edition, Holcomb Hathaway

Publishers, 2004. ISBN: 1-890871-48-6
2. M. S. Sanders and Ernest J. McCormick: Human Factors in engineering and Design, Sixth Edi.,McGraw-Hill International Editions, 1987
3. Freivalds, A., Neibel's Methods, Standards and Work Design,.McGraw Hill.
4. Martin Helander, A Guide to Ergonomics of Manufacturing, TMH, 1996.

References:

1. Konz SA & Johnson S. Work Design: Occupational Ergonomics. 7th Edition, Holcomb Hathaway Publishers, 2008. ISBN: 1-890871-79-6
2. Bridger, RS: Introduction to Ergonomics, 2nd Edition, Taylor &Francis, 2003.
3. Dul, J. and Weerdmeester,B.Ergonomics for beginners, a quick reference guide, Taylor & Francis, 1993.
4. Green, W.S. and Jordan,P .W, Human Factors in Product Design, Taylor & rancis, 1999.
5. Industrial Design for Engineers - Mayall W.H. - London Hiffee books Ltd. -1988.
6. Applied Ergonomics Hand Book - Brain Shakel (Edited) - Butterworth scientific. London - 1988.
7. Introduction to Ergonomics - R. C. Bridger - McGraw Hill Publications - 1995.
8. Human Factor Engineering - Sanders & McCormick - McGraw Hill Publications – 6 th edition, 2002.

Title of the Course: Cost Management of Engineering Project Course Code:PMDN0230	L	T	P	Credit
	3	1	-	4

Course Pre-Requisite: Basic knowledge of Process Engineering,

Course Description: Engineering management relies on the knowledge of engineering economics to be able to evaluate projects from a financial perspective. Optimizing financial performance of a project is a key responsibility of an engineer in the decision making process. This course is designed to present engineering students the major concepts and techniques of costing that are needed in the decision making process. The emphasis of this course is on the analytical analysis of cost calculation of component.

Course Objectives:

1. To acquire knowledge of Costing to be able to evaluate component/product from a financial perspective.
2. To apply analytical formulae to determine the cost of a component.
3. To present engineering students the major concepts and techniques of costing and cost control analysis that are needed in the decision making process
4. To emphasize the strong correlation between engineering design and manufacturing of products/systems and the economic issues they involve.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	**Define** elements of cost, demand and supply.	I	Remembering
CO2	**Estimate** the cost of a component.	V	Evaluate
CO3	**Evaluate** projects from a financial perspective.	V	Evaluate
CO4	**Identify** engineering economic analysis problems.	III	Applying
CO5	**Explain** the effects of depreciation, taxes, inflation and price change.	II	Understanding
CO6	**Evaluate** the depreciation of an asset using standard depreciation techniques to assess its impact on present	V	Evaluate

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	1		
CO2		2	
CO3			2
CO4	1		
CO5	1		
CO6		2	

1:low, 2:medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:---Introduction **1.1** Definition and scope of Concept of cost, cost unit, cost center, classification of cost. Definition of costing, cost-price-profit equation. Cost Estimating: Definition, purpose and functions of Cost Estimation, role of Estimator, estimating procedures. **1.2**, Break Even Analysis.	6**Hrs.**
Unit 2:---Depreciation **2.1** Elements of Cost, Depreciation Causes of depreciation of assets. Calculation of depreciation values using different methods of depreciation **2.2** Review of purchasing procedure, recording of stock and consumption of Material by LIFO, FIFO, Weighted average method. (numerical on above)	6**Hrs.**
Unit 3:---Estimation **3.1** Process of breaking down product drawing into simpler elements or shapes, estimating the volume, weight and cost (Numerical treatment). Project : Deign to Cost, Design to value, Design to Affordability,Design to Schedule,Design to Performance, Cost of Quality, Project Life cycle cost Cost Analysis : Choice Among alternatives, Cash Flows, Time Value of Money, Equivalence, Economic worth **3.2**Pattern cost estimation: material, labor, overheads, estimation of foundry costs material,labor and other costs.	8**Hrs.**
Unit 4:--- Project Progress and Cost Control Progress measurement and earned values, Earned Values for variable budgets, Tracking Cost and Schedule performance, Performance and Productivity Management.	7 **Hrs.**
Unit 5:--- Project Management **5.1** Sources of funds for business organization Concepts of wants, scarcity, choice, opportunity cost, Project cost determination, Contracting for capital Projects, Strategic asset	7**Hrs.**

Management. **5.2**Methods of Overhead Allocation, apportionment, absorption of overheads.(Numerical) **5.3**Cost Accounting Methods:Job costing, Batch costing, Unit costing, Process costing, Contract costing, Activity based costing. (numerical) **5.4 Project Financial Progress:** Calculating ETC (Estimate to Complete) and EAC (Estimate at Completion) Tracking Project Completion, Risk Management	
Unit 6:---Cost Control and Cost Reduction Budgetary control, Budget objectives, classification of budgeting, standard costs, variance analysis, marginal cost, , value analysis and value engineering, Zero Base Budgeting. Time value of money. The cash flow diagram.	6 **Hrs.**

Textbooks:

1. Mechanical Estimating and Costing By B.P. Sinha. Tata McGraw Hill Publishing Co. Ltd. N. Delhi
2. Mechanical Estimating and Costing T.R. Banga and S.C.Sharma, Khanna Publishers, Delhi-6

References:

1] Principles & Practice of Cost Accounting – N. K. Prasad (Book Syndicate Pvt. Ltd.)
2. Costing Simplified: Wheldom Series – Brown &Owier (ELBS)
3. Cost Accounting: B. Jawaharlal (TMH)
4. Cost Accounting: R.R. Gupta.
5. Cost Accounting, 13/e - B. K. Bhar, (Academic Publishers, Kolkata)
6. Cost Accounting: Jain, Narang (Kalyani Publishers)
7. A Text Book of Estimating and Costing Mechanical – J.S. Charaya& G. S. Narang (SatyaPrakashan)
8. Mechanical Estimation and Costing – TTTI, Chennai (TMH)
9. Theory & Problems of Management & Cost Accounting – M.Y. Khan, P. K. Jain (TMH)

Unit wise Measurable students Learning Outcomes:

1. Student will be able to distinguish elements of cost.
2. Calculate depreciation and value of stock.
3. Estimate weight of a given component and cost of machining.
4. Explain the process of cost estimation of forging, welding etc.
5. Calculate overhead cost, cost accounting methods.
6. Identify cost reduction techniques and estimation of budget.

Title of the Course: Condition Monitoring and Fault Diagnosis	L	T	P	Credit
Course Code: PMDN0231	3	1	-	4

Course Objectives:

1. To prepare the students to succeed as designer in industry/technical profession.
2. To provide students with a sound foundation in noise and vibration control to & solve the problems in process industry.
3. To train the students with good design engineering breadth required for safe and efficient design,
construction, installation, inspection ,testing and certification of machines.
4. To aware the students about application of monitoring methods for preventive maintenance.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Applying knowledge for preventive maintenance	3	Apply
CO2	Solve the problems related to noise and vibrations	4	Solve
CO3	Design the machine and system with minimum noise and vibrations	6	Create

CO	PO1	PO2	PO3
CO1	3	3	
CO2	3	3	
CO3	2		3

1:low,2:medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:--- Introduction to condition monitoring, different monitoring techniques, Aspect of maintenance, Vibration monitoring, fluid monitoring, ferrometry, spectroscopy, magnetic plug	**5 Hrs.**
Unit 2:--- Vibration problems in machines, Critical speed of the machines, Mechanical faults in the machines and their vibration characteristics, unbalance, misalignment, faulty gears and bearings, vibration problem related to the foundation. Transmissions of vibration and its isolation	**8 Hrs.**
Unit 3:--- Condition monitoring through vibration measurement and analysis ,	**7 Hrs.**

monitoring procedure, monitoring data sheets, vibration severity criteria, frequency analysis and time wave form analysis for fault diagnosis, rectification of mechanical faults, Dynamic balancing of machines	
Unit 4:--- Fundamentals of sound, propagation of sound waves, simple and complex sound waves, Energy in sound, reflection and transmission of sound, reflection, transmission and absorption coefficients, Decibel scale, Sound transmission through panels, Noise source characteristics ,volume source.	**7 Hrs.**
Unit 5:--- Fundamentals of noise control, criteria for noise control, Relationship of noise criteria to sound specifications, damage risk and speech interference criteria, Acoustic absorption and transmission loss, mechanism of sound transmission loss, measuring sound absorption , room acoustics ,Noise control by barriers	**8 Hrs.**
Unit 6:--- Noise control of gears, cams, bearings ,belts and fans and blowers	**5 Hrs.**
Textbooks: **Textbooks:** 1 S. S. Rao, "*Mechanical Vibration*", pear son education,1st edition,2007. 2 J. H. William and others, "*Condition Based Maintenance and M/C Diagnostics*", Business & economics, 2nd edition, 1994 3 L.L. Faulkner, "*Hand book of noise control"*, Industrial press, 2004.	
References: 1. M.C. Junger and D. Feit, "*Sound Structure and Their Interaction"*, MIT press, 1995	

Title of the Course: FINITE ELEMENT ANALYSIS LAB.	L	T	P	Credit
Course Code: PMDN0237	-	-	2	1

Course Pre-Requisite:

1. Stiffness of spring
2. Material properties
3. Creation of nodes, elements
4. Global stiffness matrix

Course Description:

This laboratory is aimed to provide hoe FEA software can be used to solve simple solid mechanics, heat transfer problems.

Course Objectives:

1. To study steps used in FEA software for solving problems.
2. To study how number of nodes and elements are created.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Create nodes and elements for analyzing cluster of springs.	2	Explain
CO2	Develop elemental node connectivity to analyze 1D bar element	3	Develop
CO3	Develop elemental node connectivity to analyze 2D truss element	3	Select
CO4	Carry out heat transfer through composite wall	5	Carry out
CO5	Perform non-linear analysis on beams, bars	5	Perform

CO-PO Mapping:

CO	1	2	3
CO1	1		
CO2		1	
CO3		2	
CO4		2	
CO5			3

1:low, 2:medium,3: high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE	50
MSE	-
ESE	50

ISE is based on assignment/declared test/quiz/seminar/Group Discussions etc.

ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:--- 1-D Element Problems –Linear Static Analysis	**2 Hrs.**
Unit 2:--- 2-D Element Problems – Linear Static Analysis	**2 Hrs.**
Unit 3:--- 3-D Element Problems – Linear Static Analysis	**2Hrs**
Unit 4:--- Free Vibration Analysis on Beam, Bars ,Plates	**2Hrs**
Unit 5:--- Non-Linear Analysis of 1-D Element Problems Like Beams, Bars	**2Hrs**
Unit 6:--- 1-D Element Problems-Steady state And Transient Analysis	**2Hrs**
Unit 7: -- 2-D Element Problems of Homogeneous and Composite Slap in Steady State and Transient Analysis	**2Hrs**
Unit 8: -- 3-D Element Problems Steady State Analysis	**2Hrs**
Unit 9: -- Project-Creating or Importing and Map Meshing of 3-D component /Assembly of practical application and FEA Analysis of Same component /Assembly	**2Hrs**
Note- • Minimum two problems shall be solved with hand calculations. •Term work shall be assessed on the basis of completion of above assignments and submission of reports. • Practical examination: Duration 3 hours – Each candidate shall carry out analysis using suitable FEA software followed by oral examination.	

Textbooks:

1. Finite Element Analysis using Ansys 11.0 by PaletiShrinivas, KrishaChaitnaySambana,Rajesh Kumar Datti.
2. Finite Element Analysis Theory and Applications with ANSYS by SaeedMoaveni
3. Engineering Analysis with ANSYS Software by Y. Nakasone and S. Yoshimoto
4. The finite element method And applications inEngineering using Ansys® by ErdoganMadenci,IbrahimGuven
5. Practicle Finite Element Analysis by NitinGokhale of M/S Finite to Infinite.
6. Reference Manual of Hypermesh Software
7. Online Tutorial HyperMesh Software.
8. Tutorial of Ansys Software.

Title of the Course: Condition Monitoring and Fault Diagnosis Lab Course Code: PMDN0238	L	T	P	Credit
	-	-	2	1

Course Objectives:

1. To prepare the students to succeed as designer in industry/technical profession.
2. To provide students with a sound foundation in noise and vibration control to & solve the Problems in process industry.
3. To train the students with good design engineering breadth required for safe and efficient design, construction, installation, inspection ,testing and certification of machines.
4. To aware the students about application of monitoring methods for preventive maintenance.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Applying knowledge for preventive maintenance	3	Apply
CO2	Solve the problems related to noise and vibrations	4	Solve
CO3	Design the machine and system with minimum noise and vibrations	6	Create

CO	PO1	PO2	PO3
CO1	3	3	
CO2	3	3	
CO3	2		3

1:low,2:medium, 3:high

Course Contents:

Experiment 1: Study and demonstration of vibration measuring instruments.	
Experiment 2 : Study of IoT based condition monitoring	
Experiment 3: Study of NDT methods used for condition monitoring.	
Experiment 4 : Case study of Bearing fault analysis using vibration measurement	
Experiment 5 : Case study of Gear box fault analysis using vibration measurement	
Experiment 6: Case study of analysis of vibrations due to unbalance.	
Experiment 7: Vibration analysis of rotating element using FEA software.	
Experiment 8: Noise measurement of various rotating elements and identify their condition.	

Textbooks:

1 S. S. Rao, "*Mechanical Vibration*", pear son education,1st edition,2007.
2 J. H. William and others, "*Condition Based Maintenance and M/C Diagnostics*", Business & economics, 2nd edition, 1994
3 L.L. Faulkner, "*Hand book of noise control"*, Industrial press, 2004.

References:

1. M.C. Junger and D. Feit, "*Sound Structure and Their Interaction"*, MIT press, 1995

Title of the Course: Design Engineering Lab Course Code: PMDN0239	L	T	P	Credit
	-	-	2	1

Course Objectives:

1) To impart practical knowledge of design engineering concepts.

2) To make aware of scope of research and development in design engineering field.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Identify and analyze practical design engineering problems.	3	Apply
CO2	Model the problem and design experiment to study the practical design engineering problems.	4	Solve

CO	PO1	PO2	PO3
CO1	3	3	
CO2	3	3	

1:low,2:medium, 3:high

Course Contents:

Experiment 1: Dynamic analysis of 4-bar chain planer mechanism.	
Experiment 2: FMEA of any manufacturing process carried out in industry.	
Experiment 3: A case study of use of ergonomics in product design.	
Experiment 4: Study of process flow diagram of any process industry. (Example- Sugar factory, Dairy, food processing unit)	
Experiment 5: Case study of use of Reverse Engineering technique.	
Experiment 6: Preparing model of mechanical component using 3-D printer.	
Experiment 7: To find mechanical properties of material using Tensile test, Impact test, Hardness test.	
Experiment 8: To carry out strain measurement using strain gauge.	
Experiment 9: Cost management study of designing a product.	
Experiment 10: Study of environmental factors considered while designing a product.	

Title of the Course: Computer Aided Design Laboratory Course Code: PMDN0240	L	T	P	Credit
	-	-	2	1

Course Pre-Requisite: Knowledge of Machine drawing, isometric and orthographic projection is essential.

Course Description: Under this course the student will be introduced to the principles of parametric design using computer aided design software. Students will construct 3 models and surfaces. Topics will include sketching, constraining, solid modeling, surface modeling, Drafting and Assembly modeling and kinematics,

Course Objectives:

1.To explain the computer aided design process by taking into account current CAD practices
2.To build/Construct Build 2D sketches fulfilling appropriate dimensional and geometrical constraints using CAD software
3.To design 3D solid Models and surface models of parts using CAD software.
4.To Construct 2D projections from 3D models and assemblies.
5.To find the physical properties like Volume, Surface area, Centre of Gravity and Moment of inertia of a given 3D solid model using suitable CAD software
6.To Develop 3D assemblies using CAD software taking into consideration appropriate assembly approach.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Explain the computer aided design process by taking into account current CAD practices.	II	Explain
CO2	Build 2D sketches fulfilling appropriate dimensional and geometrical constraints using CAD software.	III	Build
CO3	Design basic and advanced 3D solid Models and surface models of parts using CAD software.	IV	Design
CO4	Construct 2D projections from 3D models and assemblies	IV	Construct
CO5	Develop 3D assemblies using CAD software taking into consideration appropriate assembly approach	VI	Develop

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	1		2
CO2			2
CO3	2		3
CO4		1	2
CO5			2

1:low, 2:medium, 3:high

Assessments :

Teacher Assessment:

One component of In Semester Evaluation (ISE) and one End Semester Examination (ESE) having 50%, and 50% weights respectively.

Assessment	Marks
ISE	50
ESE	50

ISE are based on practical performed/ Quiz/ Mini-Project assigned/ Presentation/ Group Discussion/ Internal oral etc.
ESE: Assessment is based on oral examination

Course Contents:

1: Introduction to CAD: Concept of CAD/CAM/CAE Need for implementing CAD, Application and benefits of CAD, Hardware Requirements, Different Software packages used for 3D Modeling.	2 **Hrs.**
2: Sketching: 2D sketching of elements like line, circle, arc, spline etc. Dimensioning these elements, Geometrical constraints like parallel, perpendicular, co-incident, vertical, horizontal, tangent, symmetric etc.	2 **Hrs.**
3:Solid Modeling: Concept of Feature based and parametric modelling. Generation of Solid models of any 8 industrial components using any suitable high end 3D modeling software package. Import and export of 3D solid models between two different software packages. Physical properties like volume, surface area, center of gravity etc of solid model.	8 **Hrs.**
4: Surface Modeling: Concept of parametric surface modelling. Generation of surface models of any 5 industrial components using any suitable high end 3D modeling software package.	4 **Hrs.**
5: Assembly Modeling and Kinematics: Concept of Bottom up and top down approach, Building two composite assemblies of components (consisting at least five components) along with all relevant details, Exploded Views using assembly features in any suitable 3D modeling software. Kinematic Simulation of assembly using appropriate tool in the high end CAD software.	4 **Hrs.**
6: Generation of 2D Drawings: Generation of Orthographic views of individual components required for shop floor [working drawings] from 3D model which will include all relevant views like front, side, top, bottom views, sectional views, dimensioning, dimensional and geometrical tolerances etc. Generation of title block in sheet. Orthographic views of assembly drawings, generation of Bill of Materials (BOM). Plotting of drawings.	4 **Hrs.**

References:

1. Various 3D modeling Software Manuals.
2. CAD / CAM, Theory and Practice by Zeid, (TMH)
3. CAD / CAM, Principles & Applications by P. N. Rao (TMH)

Experiment wise Measurable students Learning Outcomes:

1. Students shall be able to explain the computer aided design process by taking into account

current CAD practices
2. Students shall be able to build/Construct Build 2D sketches fulfilling appropriate dimensional and geometrical constraints using CAD software
3. Students shall be able to to design 3D solid Models and surface models of parts using CAD software.
4. Students shall be able to Construct 2D projections from 3D models and assemblies.
5. Students shall be able to find the physical properties like Volume, Surface area, Centre of Gravity and Moment of inertia of a given 3D solid model using suitable CAD software
6. Students shall be able to Develop 3D assemblies using CAD software taking into consideration appropriate assembly approach.

Title of the Course: Industry 4.0*	L	T	P	Credit
Course Code: PMDN0262	2	-	-	-

Course Pre-Requisite: None

Course Description: The fourth industrial revolution is about to change the way industries are performing. The key technologies will disrupt the way day to day industrial activities are performed. Specifically the practices in designing the products and processes are targeted in this course. The said course will introduce students to concepts and terminologies the fourth industrial revolution so that students will be having competitive advantages in the industrial environment.

Course Objectives:

1. To provide post-graduates of mechanical- design engineering with fundamental knowledge in the fourth revolution terminologies and technologies.
2. To introduce post graduates of mechanical- design engineering with digital twin based approach in designing the products and processes.
3. To create awareness amongst mechanical- design of benefits, limitations and implications of industry 4.0.

Course Learning Outcomes:

CO	After the completion of the course, the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	**Summarize** the evolution and different terminologies in industry 4.0.	II	Understanding
CO2	**Explain** key components and applications of industry 4.0.	II	Understanding
CO3	**Illustrate** mechanical design engineering approaches with respect to industry 4.0	II	Understanding

CO-PO Mapping:

CO	1	2	3
CO1	3	2	
CO2	3	2	
CO3	3	2	

1:low, 2: medium, 3:high

Assessments:

Teacher Assessment:

The assessment will be based on end semester theory exam (ESE) on entire syllabus.

Assessment	Marks
ESE	100

Course Contents:

Unit 1: Introduction and Evolution of INDUSTRY 4.0: Flow line, TPS, job shop and cell for industry 2.0, FMS and Seru for Industry 3.0, Comparisons of Seru with the TPS and Cells, Potential manufacturing for Industry 4.0, Smart manufacturing for Industry 4.0, An example of a smart manufacturing system for Industry 4.0, Time line of Industry 1.0–4.0, Demand dimensions for Industry 4.0, Modular design for vehicles	**05 Hrs.**
Unit 2: Key Components of I4.0: Big Data, Cloud Manufacturing, Internet of Things, Autonomous Robots, Simulation, Horizontal and Vertical Systems Integration, Cyber Security, Additive Manufacturing, Augmented Reality The Smart Factory of the I4.0: . Cyber-Physical Systems, Internet of Services	**07 Hrs.**

Unit 3: Design for and with industry 4.0: Design for Industry 4.0, Design with Industry 4.0, PGE – Product Generation Engineering, Modelling of interdependencies between product and production system, General approach for Design with and Design for Industry 4.0, Modelling of interdependencies between product function, embodiment and production process.	**04 Hrs.**
Unit 4: Digital Twin based approach in designing mechanical components: Definitions of the Digital Twin, Application Examples of Digital Twins, The geometry assurance process. The Digital Twin in the design phase, Functionality: locating scheme optimization, Functionality: statistical variation simulation, The Digital Twin in the pre-production phase: Functionality: inspection preparation, The Digital Twin in the production phase: Functionality: virtual trimming, Functionality: joining sequence optimization, Functionality: root cause analysis (RCA), Digital Twin input and functionality.	**06 Hrs.**
Unit 5: Current Status of industry 4.0 implementation and impact of implementation, Design prerequisites for Industry 4.0, Smart machines, Machine learning, Benefits of Industry 4.0, Limitations of Industry 4.0	**03 Hrs.**
Unit 6:- Other Applications and Case Studies Industry 4.0: Xiaomi case, The Digital Twin – a sheet metal assembly example, Concept of SmartCorrect, GE Digital Twin, A digital twin for the city of Newcastle, Digital Twin in automobile	**03 Hrs.**

Textbooks:

1. Industry 4.0: Managing The Digital Transformation by Alp Ustundag, Springer Publication
2. Industry 4.0: Industrial Revolution of the 21st Century, by Elena G. Popkova, Yulia V. Ragulina, Aleksei V. Bogoviz
3. Augustine, P. (2019). The industry use cases for the Digital Twin idea. In *Advances in Computers* (1st ed.). https://doi.org/10.1016/bs.adcom.2019.10.008

References:

1. Industry 4.0: The Industrial Internet of Things", by Alasdair Gilchrist (Apress)
2. "Industrial Internet of Things: Cybermanufacturing Systems"by Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat (Springer)
3. Yin, Y., Stecke, K. E., & Li, D. (2018). The evolution of production systems from Industry 2.0 through Industry 4.0. *International Journal of Production Research*, *56*(1–2), 848–861. https://doi.org/10.1080/00207543.2017.1403664
4. Albers, A., Stürmlinger, T., Mandel, C., Wang, J., Frutos, M. B. de, & Behrendt, M. (2019). Identification of potentials in the context of Design for Industry 4.0 and modelling of interdependencies between product and production processes. *Procedia CIRP*, *84*, 100–105. https://doi.org/10.1016/j.procir.2019.04.298
5. Alcácer, V., & Cruz-Machado, V. (2019). Scanning the Industry 4.0: A Literature Review on Technologies for Manufacturing Systems. *Engineering Science and Technology, an International Journal*, *22*(3), 899–919. https://doi.org/10.1016/j.jestch.2019.01.006
6. Wagner, R., Schleich, B., Haefner, B., Kuhnle, A., Wartzack, S., & Lanza, G. (2019). Challenges and Potentials of Digital Twins and Industry 4.0 in Product Design and Production for High Performance Products. *Procedia CIRP*, *84*, 88–93. https://doi.org/10.1016/j.procir.2019.04.219
7. Söderberg, R., Wärmefjord, K., Carlson, J. S., & Lindkvist, L. (2017). Toward a Digital Twin for real-time geometry assurance in individualized production. *CIRP Annals - Manufacturing Technology*, *66*(1), 137–140. https://doi.org/10.1016/j.cirp.2017.04.038

8. Fatorachian, H., & Kazemi, H. (2018). A critical investigation of Industry 4.0 in manufacturing: theoretical operationalisation framework. *Production Planning and Control*, *29*(8), 633–644. https://doi.org/10.1080/09537287.2018.1424960
9. Gianessi, P., Abdellaoui, E., Gianessi, P., Abdellaoui, E., & Gianessi, P. (2019). *ScienceDirect Process to to Design Industry*. 1390–1395. https://doi.org/10.1016/j.ifacol.2019.11.390
10. Mabkhot, M. M., Al-Ahmari, A. M., Salah, B., & Alkhalefah, H. (2018). Requirements of the smart factory system: A survey and perspective. *Machines*, *6*(2). https://doi.org/10.3390/MACHINES6020023
11. Romeo, L., Loncarski, J., Paolanti, M., Bocchini, G., Mancini, A., & Frontoni, E. (2020). Machine learning-based design support system for the prediction of heterogeneous machine parameters in industry 4.0. *Expert Systems with Applications*, *140*. https://doi.org/10.1016/j.eswa.2019.112869
12. Mariani, M., & Borghi, M. (2019). Industry 4.0: A bibliometric review of its managerial intellectual structure and potential evolution in the service industries. *Technological Forecasting and Social Change*, *149*(September), 119752. https://doi.org/10.1016/j.techfore.2019.119752
13. Pacchini, A. P. T., Lucato, W. C., Facchini, F., & Mummolo, G. (2019). The degree of readiness for the implementation of Industry 4.0. *Computers in Industry*, *113*, 103125. https://doi.org/10.1016/j.compind.2019.103125
14. Szozda, N. (2017). *LogForum*. *13*(4), 401–414.

Unit wise Measurable students Learning Outcomes:

1. The student will be able to summarize industrial revolutions 1.0-4.0.
2. The student will be able to explain key components and technologies used in industry 4.0 and smart manufacturing.
3. The students will able to relate present design practices in the context of industry 4.0.
4. The student will be able to illustrate digital twin concepts that can be used in product and process designs.
5. The student will be able to explain implications of the industry 4.0.
6. The student will be able to explain applications and case studies in industry 4.0.