Curriculum for PG Degree Course in M. Tech. Mechanical Engineering

Academic Year: 2024-25 Onwards

First Year | Semester-I

Course Code	Course Title	Teaching Scheme Hours / Week			Cr	Examination Scheme			Total Marks
		L	T	P		ISE	ESE	Pr/Or	
24PCMME101	Research Methodology and Statistical Techniques	4	0	0	4	50	50	0	100
24PCMME102	Advanced Mechanics of Solids	3	1	0	4	50	50	0	100
24PCMME103	Optimization Methods	3	1	0	4	50	50	0	100
24PCMME104	Finite Element Analysis	3	0	0	3	50	50	0	100
24OEM101	Open Elective	3	0	0	3	50	50	0	100
24PCMME104L	Finite Element Analysis Lab	0	0	2	1	25	0	25	50
24PCMME105L	Applied Data Science for Mechanical Engineering Lab	0	0	2	1	25	0	25	50
	Total =	**16**	**2**	**4**	**20**	**300**	**250**	**50**	**600**

First Year | Semester-II

Course Code	Course Title	Teaching Scheme Hours / Week			Cr	Examination Scheme			Total Marks
		L	T	P		ISE	ESE	Pr/Or	
24PCMME201	Advanced Mechanical Vibrations	3	0	0	3	50	50	0	100
24PCMME202	Advanced Machine Design	3	1	0	4	50	50	0	100
24PCMME203	Design of Electric Vehicle System	3	1	0	4	50	50	0	100
24PCMME204	Industrial Robotics	3	0	0	3	50	50	0	100
24PEMME201	Programme Elective	3	0	0	3	50	50	0	100
24PCMME201L	Advanced Mechanical Vibrations Lab	0	0	2	1	25	0	25	50
24PCMME204L	Industrial Robotics Lab	0	0	2	1	25	0	25	50
24PEMME201L	Programme Elective Lab	0	0	2	1	25	0	25	50
	Total =	**15**	**2**	**6**	**20**	**325**	**250**	**75**	**650**

L=Lecture, T=Tutorial, P= Practical, Cr= Credits, ISE =In Semester Evaluation, ESE =End Semester Examination, Pr/Or = Practical/Oral

Open Elective:

A. Intellectual Property Rights
B. Organisational Behaviour

Programme Elective:

A. Product Design for Manufacturing and Assembly
B. Manufacturing and Mechanics of Composite Materials

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Curriculum for PG Degree Course in M. Tech. Mechanical Engineering

Academic Year: 2024-25 Onwards

Second Year | Semester-I

Course Code	Course Title	Teaching Scheme Hours / Week			Cr	Examination Scheme			Total Marks
		L	T	P		ISE	ESE	Pr/Or	
24VSECMME301	Skill Enhancement Course#	4	0	0	4	50	50	-	**100**
24INTRM301	Internship based project	--	--	12* Weeks	16	100	-	100	**200**
Total =		4	0	0	**20**	**150**	**50**	**100**	**300**

- This course can be learned in online self-learning mode *[of Min. 8 weeks duration & available on NPTEL platform]* #
- Minimum duration for Internship 12 weeks *

Second Year | Semester-II

Course Code	Course Title	Teaching Scheme Hours / Week			Cr	Examination Scheme			Total Marks
		L	T	P		ISE	ESE	Pr/Or	
24VSECMME401	Technical / Research Report / Paper writing	4	0	0	4	50	50	-	**100**
24INTRM401	Internship based project	--	--	14* Weeks	16	100	-	100	**200**
Total =		4	0	0	**20**	**150**	**50**	**100**	**300**

- Minimum duration for Internship 14 weeks *
- *L=Lecture, T=Tutorial, P= Practical, Cr= Credits, ISE =In Semester Evaluation, ESE =End Semester Examination, Pr/Or = Practical/Oral*

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24PCMME101 Research Methodology and Statistical Techniques

Teaching Scheme
Lecture: 4 Hrs/week

Examination Scheme
In semester: 50 marks
End semester: 50 marks
Credits: 4

Course Objectives:
1. To introduce students to research methodology principles, including problem formulation and literature review.
2. To develop skills for ethical research practices and effective data collection methods.
3. To enable students to analyze data using fundamental statistical methods.
4. To teach students how to evaluate relationships between variables through regression and ANOVA.
5. To equip students with knowledge of advanced statistical techniques for engineering research.

Course Outcomes:
On completion of the course, students will be able to -
1. Conduct a thorough literature review and develop research questions and hypotheses based on research methodology principles.
2. Apply ethical standards and appropriate sampling techniques in the data collection process.
3. Analyze data using descriptive statistics, probability distributions, and hypothesis testing.
4. Evaluate relationships between variables using regression and ANOVA techniques.
5. Implement advanced statistical methods, including DOE and multivariate analysis, in engineering research.

Unit 1: Foundations of Research

Research Fundamentals (Definition, Objectives, Types of Research), Research Process (Steps from Problem Identification to Reporting), Formulation of Research Problem (Research Questions, Hypothesis Development, Defining Scope), Research Design (Types: Descriptive, Analytical, Experimental, Methods), Literature Review (Importance, Sources, Techniques for Effective Review). Research Ethics (Plagiarism, Data Fabrication, Informed Consent, Ethical Approval Processes)

Layout of a Research Paper, Journals in Mechanical Engineering, Impact factor of Journals, When and where to publish? Ethical issues related to publishing, Plagiarism and Self-Plagiarism**.**

Unit 2: Data Collection and Sampling

Introduction to Data Collection, Methods of Data Collection, Surveys and Questionnaires, Interviews, Observations, Focus Groups, Experiments, Document and Content Analysis, Sampling Techniques, Probability Sampling Methods, Simple Random Sampling, Stratified Sampling, Systematic Sampling, Cluster Sampling, Non-Probability Sampling Methods, Convenience Sampling, Purposive Sampling, Snowball Sampling, Quota Sampling, Sampling errors

Unit 3: **Statistical Data Analysis**

Descriptive Statistics (Measures of Central Tendency: Mean, Median, Mode, Variability: Variance, Standard Deviation, Data Representation: Graphs, Tables), Probability Distributions (Normal, Binomial, Poisson Distributions, Applications), Hypothesis Testing (Null and Alternative Hypotheses, Types of Errors, Z-Test, T-Test, Chi-Square Test), Confidence Intervals (Meaning, Calculation, Interpretation).

Unit 4: **Regression and Correlation Analysis:**

Correlation (Pearson, Spearman Correlation Coefficients), Linear Regression (Simple, Multiple Regression Analysis, Least Squares Method, Applications), ANOVA (Analysis of Variance: One-way, Two-way, Applications), Non-Parametric Tests (Mann-Whitney, Kruskal-Wallis Tests, Applications).

Unit 5: **Advanced Statistical Techniques**

Design of Experiments (DOE: Full Factorial, Fractional Factorial Designs Methods), Multivariate Analysis (Principal Component Analysis: PCA, Cluster Factor Analysis), Time Series Analysis (Trends, Seasonal Variations, Forecasting Reliability Engineering and Statistical Quality Control (SQC: Control Chart Capability, Applications in Manufacturing).

Books:

1. Kothari, C. R., & Garg, G. Research Methodology: Methods and Techniques (4th ed.). New Age International Publishers.
2. Panneerselvam, R. Research Methodology (2nd ed.). PHI Learning Pvt. Ltd.
3. Gupta, S. C., & Kapoor, V. K. Fundamentals of Mathematical Statistics (12th ed.). Sultan Chand & Sons.
4. Das, N. G. Statistical Methods . McGraw Hill Education.
5. Montgomery, D. C. (2019). Design and Analysis of Experiments (8th ed., Indian Student Version). Wiley India.

24PCMME102 Advanced Mechanics of Solids

Teaching Scheme	**Examination Scheme**
Lecture: 3 Hrs/week	In semester: 50 marks
Tutorials: 1 Hrs/week	End semester: 50 marks
	Credits:4

Pre-Requisites:
Applied Mechanics, Strength of Materials, Engineering Materials

Course Objectives:
Introduce students to -

1. Theory of elasticity
2. Theory of plasticity
3. Fracture mechanics and fatigue behaviour of material.
4. Nature and behaviour through experimental stress analysis

Course Outcome:
On completion of the course, students will be able to -

1. Apply concepts of theory of elasticity to the problems on stress and strain analysis
2. Apply concepts of theory of plasticity to the problems on stress and strain analysis
3. Analyse the fracture mechanics and fatigue failure of the material.
4. Understand the concepts of experimental stress analysis

Unit 1: Theory of Elasticity

Analysis of stress and strain, Stress–Strain Relations for Linearly Elastic Solids, Yield Criteria and Introduction to ideally Plastic Solid.

Unit 2: Theory of Plasticity

Non-linear material response, Yield criteria: maximum principal stress criteria, maximum principal strain criteria, strain-energy density criteria, alternative yield criteria, general yielding.

Unit 3: Contact Stresses

Geometry of contact surfaces, method of computing contact stresses and deflection of bodies in

point contact, stress for two bodies inline contact with load normal to contact area and load normal and tangent to contact area, gear contacts, contacts between cam and follower, ball bearing contacts.

Unit 4: Introduction to fatigue and fracture mechanics

Stress life: S-N diagram, Mean stress effect, modifying factors, Strain-life: material behaviour, strain-life curve, fatigue properties, mean stress effect, Brittle Fracture, Stress Intensity Factor, Fracture Toughness, Fracture Conditions, Fracture Modes, Plane Stress and Plane Strain, Plastic

Collapse at a Notch, Experimental Determination of K_{IC}, Strain-Energy Release Rate, Meaning of Energy Criterion, Design Consideration.

Unit 5: Experimental stress analysis

Dimensional analysis, analysis techniques, strain gauges, types of strain gauges, materials, configuration, instrumentation, characteristics of strain gauge measurement, theory of photoelasticity, elements of polariscope, simple and circular polariscope, fringes in dark and white field, isoclinic and isochromatic fringe patterns, evaluation of stresses from these fringe patterns.

Books

1. Advanced Mechanics of Solids, L. S. Srinath, Tata McGraw-Hill
2. Advanced Mechanics of Materials, A. P. Boresi, Wiley
3. Theory of Elasticity, S. P. Timoshenko, Mc Graw Hill
4. Fundamentals of metal Fatigue, J. A. Bannantine, Prentice Hall
5. Mechanics of Composite Materials, A. K. Kaw, CRC Press

24PCMME103 Optimization Methods

Teaching Scheme
Lecture: 3 Hrs/week
Tutorials:1 Hrs/week

Examination Scheme
In semester: 50 marks
End semester: 50 marks
Credits: 4

Pre-Requisites:

Course Objectives:

1. To introduce to the student's optimization problems and various solution techniques,
2. To impart knowledge of various classical and modern optimization techniques.
3. To make students aware about industrial optimization problems
4. To expose students to numerical techniques to solve optimization problems.

Course Outcome:

On completion of the course, students will be able to -

1. formulate objective functions and constraint equations for a given classical problem
2. apply classical and modern method of optimization to standard problems
3. solve realistic and industrial design problems.
4. use computational tools such as MATLAB/OCTAVE to get solutions

Unit: 1 Introduction to Optimization

Engineering Applications of Optimization, Statement of an Optimization Problem, Classification of Optimization Problems, Graphical Optimization Techniques

Unit: 2 Classical Optimization Techniques

Single-Variable Optimization, Multivariable Optimization with No Constraints, Multivariable Optimization with Equality Constraints: Solution by Direct Substitution, Solution by the Method of Constrained Variation, Solution by the Method of Lagrange Multipliers, Multivariable Optimization with Inequality Constraints: Kuhn–Tucker Conditions, Constraint Qualification, Convex Programming Problem

Unit: 3 Linear Programming: Simplex Method

Applications of Linear Programming,Standard Form of a Linear Programming Problem, Simplex Algorithm, Two Phases of the Simplex Method

Unit: 4 Nonlinear Programming

Introduction, Unrestricted Search, Interval Halving Method, Golden Section Method, Quadratic Interpolation Method, Newton's Method, Practical Considerations

Unit: 5 Modern Methods of Optimization

Genetic Algorithms, Simulated Annealing, Particle Swarm Optimization, Neural-Network-Based Optimization, Practical Aspects of Optimization, Intro to Special Optimization Methods as Dynamic Programming, Optimal Control

Books:

1. Engineering Optimization -Theory and Practice/ Singerusu S. Rao/ New Age.
2. Optimum Design of Mechanical elements/ Johnson Ray C/ Wiley, John & Sons
3. Optimization for Engineering Design Algorithms and Examples/ Kalyanamoy Deb/Prentice Hall of India

24PCMME104 Finite Element Analysis

Teaching Scheme	**Examination Scheme**
Lecture: 3 Hrs/week	In semester: 50 marks
Tutorials: Nil	End semester: 50 marks
	Credits: 3

Pre-Requisites: Numerical Method, Engineering Mechanics, Computer Aided Design

Course Objectives:

1. To understand the philosophy and general procedure of Finite Element Method as applied to solid mechanics and thermal analysis problems.
2. To familiarize students with the displacement-based finite element method for displacement and stress analysis and to introduce related analytical and computer tools.
3. To provide a bridge between hand calculations based on mechanics of materials and machine design and numerical solutions for more complex geometries and loading states.
4. To study the approximate nature of the finite element method and convergence of results are examined.
5. To provide some experience with a commercial FEM code and some practical modeling exercises

Course Outcome:

On completion of the course, students will be able to -

1. Derive and use element stiffness matrices from various methods to solve bar, truss, and beam problems.
2. Apply the finite element method to formulate and solve 2D plane stress, and plane strain problems.
3. Apply Iso-parametric elements formulation for solving the 2D problem of solid mechanics.
4. Apply the finite element method for solving the heat transfer problem.
5. Dynamic analysis of structural engineering problem using FEM

Unit 1: Introduction to FEM and Formulation of Bar, Beam, and Trusses

Finite element method, brief history, basic steps, advantages and disadvantages, One Dimensional Problem: Finite element modeling, coordinate and linear shape function, Assembly of Global Stiffness Matrix and Load Vector, Properties of Stiffness Matrix, Finite Element Equations, (stepped bar), Temperature Effects, Penalty approach,

Trusses: Introduction, 2D Trusses, Element stiffness matrix for truss, Assembly of Global Stiffness Matrix, load vector

Beam: Development of beam equation, beam stiffness matrix, an assemblage of beam stiffness matrices, Examples of beam analysis, and Beam element with distributed loading.

Unit 2: 2D Finite Element Method

Plane Stress/Strain problems: Concept of plane stress, plane strain, Constitutive relations, Constant Strain Triangle (CST), Liner Strain Triangle (LST) and Linear Strain Rectangle (LSR) element, displacement function, Pascal's triangle, compatibility, and completeness requirement, geometric isotropy, convergence requirements, strain filed, stress filed. Formulation of element stiffness matrix and load vector for Plane Stress/Strain problems using CST/LST, Assembly of global stiffness matrix and load vector, Boundary conditions, solving for primary variables (displacement), stress calculations

Unit 3: Iso-parametric Elements and Formulation
Introduction, shape functions – linear & quadratic, displacement function – criteria for the choice of the displacement function, polynomial displacement functions, displacement function in terms of nodal parameters, strain-nodal parameter relationship, stress-strain relationship, Iso-parametric formulation of bar and plane quadrilateral element, Evaluation of stiffness matrix by Gaussian Quadrature.

Unit 4: FEM to Heat Transfer
Introduction, Basic differential equation, Heat transfer with conduction, convection, finite element formulation with the variational method, Typical units, Thermal Conductivities, Heat Transfer Coefficients, Insulated rod, composite wall problem, and its solution using FEM.

Unit 5: Structural Dynamic and Nonlinear Analysis
Dynamic of the spring-mass system, Formulation of dynamic problems, consistent and lumped mass matrices, Derivation of bar element equation, Natural frequencies of the Bar, Beam element mass matrices, and natural frequencies. Solution of eigenvalue problems – transformation methods, Jacobi method, Vector Iteration methods
Introduction to non-linear analysis, formulation for geometrical, material, and contact nonlinear problems, and Nonlinear equation solving procedure.

Books:

1. Daryl Logan, First Course in the Finite Element Method, Cengage Learning India Pvt. Ltd.
2. Gokhale N. S., Deshpande S. S., Bedekar S. V. and Thite A. N., Practical Finite Element Analysis, Finite to Infinite, Pune
3. Seshu P., "Textbook of Finite Element Analysis", PHI Learning Private Ltd., New Delhi, 2010.
4. Reddy, J. N., "An Introduction to The Finite Element Method", Tata McGraw Hill, 2003.
5. Mukhopadhyay M and Sheikh A. H., "Matrix and Finite Element Analyses of Structures", Anne Books Pvt. Ltd., 2009.
6. Chandrupatla T. R. and Belegunda A. D., "Introduction to Finite Elements in Engineering", Prentice Hall India.

24PCMME104L Finite Element Analysis Lab

Teaching Scheme

Practical: 2 hrs/week

Examination Scheme

In semester: 25 marks
End semester: 25 marks
Credits: 1

Course Objectives:

1. To formulate a 1D FEM problem for static structural analysis
2. To use finite element tools to solve bar, beam, and truss problems of static structural analysis.
3. To use finite element tools for static structural analysis of mechanical components

Course Outcomes:

After successful completion of the course, students will be able to

1. Write a program to formulate a 1D FEM problem for static structural analysis.
2. Compute stresses, strains, and deflection of bar/beam/truss/mechanical components under static loading using the FEA tool.
3. Interpret the stresses, strains, and deflection results of bar/beam/truss/mechanical components obtained through the FEA tool.

Lab Work:

1. Write a program for deformation, strain, and stress analysis of a static structural problem as stepped bar/beams.
2. Write a program for deformation, strain, and stress analysis of trusses subjected to plane forces.
3. Static structural analysis of stepped bar/beam using the FEA tool to evaluate deformation and stresses under point load and UDL.
4. Static structural analysis of trusses using the FEA tool to evaluate deformation and stresses.
5. Static structural analysis of mechanical element/part/component i.e., plate with hole, bracket, seat belt hook, etc. subjected to axial loading using 2D elements.
6. Stress and deflection analysis of machine components consisting of 3-D elements using FEA software.
7. Steady-state thermal analysis of plate to calculate temperature distribution using FEA software.
8. Modal analysis of any machine component to find its natural frequencies using FEA software.

Textbooks/References:

1. Nitin S. Gokhale, Practical Finite Element Analysis, Finite to Infinite; First edition
2. ANSYS user guide https://www.ansys.com/academic/learning-resources

24PCMME105L Applied Data Science for Mechanical Engineering Lab

Teaching Scheme

Practical: 2 hrs/week

Examination Scheme

In semester: 25 marks
End semester: 25 marks
Credits: 1

Course Objectives:

1. To learn data visualization and data analysis techniques
2. To apply data-based techniques to engineering problems.
3. To use data analysis/ML tools for practical problems

Course Outcomes:

After successful completion of the course, students will be able to

1. obtain, clean, and process data using software tools.
2. analyze, visualize data, and draw inferences
3. write codes in Python/R for data analysis

Lab Work: Data analysis and ML problem statements shall be from the domain of mechanical engineering

1. Web scraping using Python (Beautiful Soup etc.)
2. Data Visualization (matplotlib, seaborn)
3. Statistical functions in Scipy.stats
4. Programming: Scikit learn
5. Programming: Pytorch
6. End-to-end programming assignment on data analysis/ML
7. Assignment on Kaggle competition

24PCMME201 Advanced Mechanical Vibrations

Teaching Scheme
Lecture: 3 Hrs/week
Tutorials: - Nil

Examination Scheme
In semester: 50 marks
End semester: 50 marks
Credits: 3

Course Objectives:

1. To model and analyze the multi degree of freedom system
2. To evaluate natural frequencies using numerical techniques
3. To estimate the response of a continuous vibratory system
4. To analyse structural vibration of a system using experimental modal analysis techniques
5. To evaluate modal parameters using computational modal analysis
6. To describe various vibration control methods and condition monitoring techniques

Course Outcomes: Upon completion of this course, the student will be able to,

1. model and analyze the multi degree of freedom system
2. evaluate natural frequencies using numerical techniques
3. estimate the response of a continuous vibratory system
4. analyze structural vibration of a system using experimental modal analysis techniques
5. evaluate modal parameters using computational modal analysis
6. describe various vibration control methods and condition monitoring techniques

Unit 1 . Multi Degree Freedom System
Free vibration equation of motion, influence coefficient i) stiffness coefficient (ii) flexibility coefficient generalized coordinates, coordinate couplings, Lagrange's equations, matrix method, Eigen values Eigen vector, modal analysis. Dunkerley's method, Rayleigh's Method, Methods of Matrix iterations, Jacobi diagonalization method, Holzer's Method.

Unit 2. Continuous Systems
Transverse vibrations of String, Longitudinal vibration of Rods, Torsional vibrations of Shaft, Lateral vibrations of cantilever beams

Unit 3. Experimental Vibration Analysis, Vibration measurement
Analog to Digital (A-D) Conversion, Aliasing, DFT, FFT, Windowing for Continuous, Random and Transient Signals, System Identification Using the FFT, Signal Averaging Coherence, Rules of Signal Pro cessing, Time and Frequency Domain Terminology, vibration exciters, experimental modal analysis.

Unit 4. Computational Vibration Analysis
Introduction to Laplace Method for Step input, impulse input to SDOF, Laplace Transform, Response for First Order Models, State Space system, Simulations using MATLAB and SIMULINK, Base Excitation, finding modal parameters using computational modal analysis

Unit 5. Vibration Control and Condition Monitoring
Rotating Imbalance, Balancing of rotating machine, in-situ balancing of rotors, control of natural frequency, vibration isolation and vibration absorbers, Passive, active and semi-active control, machine conditioning and monitoring, fault diagnosis

Books:

1. Engineering Vibration, Daniel J. Inman, Pearson Education
2. Mechanical Vibrations, S. S. Rao, Addison-Wesley Publishing Co.
3. Fundamentals of Vibration, Leonard Meirovitch, McGraw Hill International.
4. Principles of Vibration Control: Ashok Kumar Mallik, Affiliated East-West Press.
5. Theory of Vibrations with Applications, W. T. Thomson and Marie Dillon Dahleh, Pearson New International Edition.
6. Mechanical Vibrations, A. H. Church, John Wiley & Sons Inc.
7. Mechanical Vibrations, J. P. Den Hartog, Dover Publications.
8. Mechanical Vibration Analysis, Srinivasan, McGraw-Hill Education.
9. Mechanical Vibrations, G. K. Groover, Nem Chand & Bros.

24PCMME202 Advanced Machine Design

Teaching Scheme
Lecture: 3 Hrs/week
Tutorials: 1 Hr/Week

Examination Scheme
In semester: 50 marks
End semester: 50 marks
Credits: 4

Course Objectives:

1. To identify the characteristics and features of advanced materials applied in engineering applications.
2. To analyse fatigue failure for infinite and finite life and to apply optimum design techniques for the given machine element.
3. To apply the Raimondi and Boyd method to assess the performance of bearings in terms of dimensionless parameters.
4. To apply the relevant principles to design the given pressure vessel/process equipment.
5. To design a given material handling system by analysing power requirements.

Course Outcomes: On completion of the course the student will be able to,

1. Identify the characteristics and features of advanced materials applied in engineering applications.
2. Analyse fatigue failure for infinite and finite life and to apply optimum design techniques for the given machine element.
3. Apply the Raimondi and Boyd method to assess the performance of bearings in terms of dimensionless parameters.
4. Apply the relevant principles to design the given pressure vessel/process equipment.
5. Design a given material handling system by analyzing power requirements.

Unit 1. Advanced Mechanics and Materials: Theory of Elasticity and Plasticity, Fracture mechanics. Smart Materials, Ortho-dental materials, Bio-material, Prosthetic materials, Nano materials, superconducting materials, sports materials, composites, ceramics, cermets, shape memory alloys.

Unit 2. Fatigue Failure Analysis and Optimum Design: Design for infinite and finite life, fatigue design under combined stresses, Impact stresses. Adequate design and Optimum design, Optimum design for normal and redundant specifications.

Unit 3. Tribology of Hydrostatic and Hydrodynamic Bearings: Modes of lubrication, viscosity index, Petroff's equation, McKee's investigation, analysis of hydrostatic step bearing, Hydrodynamic lubrication, Reynold's equation, Raimondi and Boyd Method, temperature rise, Bearing Design-Selection of parameters.

Unit 4. Process Equipment Design: Design of Cylindrical and Spherical Vessels: Thin and thick walled pressure vessels, cylinders with external pressure, unfired pressure vessels, Storage vessels, reaction vessels, agitation and mixers, heat exchangers, filters and dryers, centrifuges. Code practices, selection and specification procedures used in design.

Unit 5. Material Handling Systems: Concept of Unit Load and Containerization, Selection of suitable types of material handling systems, Activity cost data and economic analysis for design of components of material handling systems, Design of conveyors and hoists.

Books:

1. 'Design for Excellence', James Bralla, Technicraft Publication.
2. 'Advanced Mechanics of Materials', Arthur P. Boresi and Richard J. Schmidt.
3. 'Machine Design: An Integrated Approach', Robert L. Norton, Wiley.
4. 'Shigley's Mechanical Engineering Design', Richard G. Budynas and Keith A. Nisbett, McGraw Hill Education.
5. 'Engineering Design–A Systematic Approach', Pahl, G.and W.Beitz, Springer.
6. 'Tribology in Machine Design', T. A. Stolarski, Butterworth Heinmann.
7. 'Process Equipment Design', Dr. M.V. Joshi, Mc-Millan.
8. 'Material Handling System Design', James M. Apple, John-Willlwy and Sons Publication.

24PCMME203 Design of Electric Vehicle Systems

Teaching Scheme
Lecture: 3 Hrs/week
Tutorials: 01 Hrs/week

Examination Scheme
In semester: 50 marks
End semester: 50 marks
Credits:4

Pre-Requisites: Basics of Electrical and Electronics Engineering

Course Objectives: To make students proficient in
1. EV technology,
2. Different types of motors and control systems,
3. Energy storage systems for EV, batteries, charging etc.
4. Various EVs in market

Course Outcomes: After successful completion of the course, student will be able to
1. Analyze dynamics of an EV
2. Analyze and select motors and design control systems for a given drive cycle
3. Analyse and design battery pack and BMS/TMS for EVs
4. Design of power train for and EV
5. Integrate various subsystems of an EV

Unit: 1 Introduction to Vehicle Dynamics and EV Systems

General principle of vehicle movement, vehicle resistance, dynamic equation, tire adhesion, tractive effort and speed, vehicle performance, brake performance, fuel economy. Configuration of EVs, various system architectures and their integration, hybrid-electric drive train, architecture of hybrid-electric drive train.

Unit: 2 Design of Energy Storage Systems

Electrochemical batteries,various battery chemistries, battery management systems, thermal management of batteries, battery sizing and analysis, design of battery pack

Unit: 3 Design of Power Train for EVs

DC motors drives, induction motor drives, BLDC motors, performance characteristics of motors, powertrain integration, control of electric motors, gear trains, design of drive train for an EV

Unit: 4 Design of BMS, TMS and Charging Systems

BMS, TMS for batteries, design of BMS and cooling systems for battery packs, Standards, charging methods, time, cost, charging modes, battery replacement, vehicle-to-grid technology, design of a Charger.

Unit: 5 Design Considerations for Integrations of EV Systems

Systems and architecture of various commercial EV cars, GM EV-1, Nissan Leaf 2016, Tesla Roadster, TATA Nexon, Ather 450x etc, layout for integration of various systems, design considerations: optimum space, weight, cost and arrangement for interaction of EV systems

Books:

1. Tom Denton, Electric and hybrid vehicles, Routledge, 2016
2. Chris Mi, M. Abul Masrur, Hybrid Electric Vehicles. Principles and Applications with Practical Perspectives, Wiley, 2016
3. K. T. Chau, Emerging Trends in Evs, MDPI AG, 2018
4. Ehasani , Gao, Longo, Modern Electric and Hybrid Vehicle, CRC, 2017

24PCMME204 Industrial Robotics

Teaching Scheme
Lecture: 3 Hrs/week

Examination Scheme
In semester: 50 marks
End semester: 50 marks
Credits: 3

Pre-Requisites: Engineering Mechanics, Physics, Mathematics, Basic Electrical and Electronics Engineering.

Course Objectives: To make the students aware of

1. Robots, robotic sub-systems, robot configurations, and functionality of industrial robots.
2. Applications of sensors and actuators for Machine Vision.
3. Control systems, types, components, Transfer Function, and Time domain analysis.
4. Implementation of different control strategies and control actions with controllers

Outcomes: Students will be able to

After a successfully completing the course, students will be able to
1. Demonstrate the capabilities of identification of robot subsystems and it's configurations
2. Analyze the sensory control systems with Machine Vision and actuation.
3. Analyze the robot kinematics - Forward Kinematics and Inverse Kinematics
4. Evaluate the system model and analyze the stability of the model with Time domain analysis
5. Estimate the performance of the control system and design the controllers with tunning.

Unit: 1 Fundamentals of Robotics

Robot definition, History and milestones, Robot Anatomy, Laws of Robotics, Robot Sub-system components, Classifications of Robots, Work volume, End effectors, AGV's, Industrial Applications.

Unit: 2 Mechatronics and Machine Vision

Elements of Mechatronics System, Mechatronics System Design,
Sensors: Types and Classification, Selection of Sensors.
Actuators-DC Motor, Stepper Motor, Servomotor, Hub Motor
Machine Vision: Elements, Sampling Theorem, Digitalization, Steps in Machine Vision system, Image Processing and Analysis.

Unit: 3 Robot Motion analysis and Control

Manipulator Kinematics, Transformation matrices, link and joint, Denavit- Hartenberg (D-H) Parameters, Kinematic Redundancy, kinematics calibration, inverse kinematics, Static force and velocity in manipulators, Motion of manipulator links, jacobians, singularities, Manipulator Path Control

Unit: 4 Modelling and Stability of Control System

System Models for Mechanical, Electrical, Electronics, Hydraulic, Thermal system, Stability Analysis in S-Domain- Poles & Zeros, Control system definition, types, classifications, Routh - Hurwitz's stability criterion.Transfer Functions, Block Diagram Reduction Techniques, Signal Flow Graph, Mason's Gain Formula

Unit: 5 Controller Design

Control strategies, On-Off, Proportional (P), Integral(I), Derivation (D) Controller and Control actions, PI, PD, PID Controller design.

Programmable Logic Controllers (PLC): PLC Architecture, Ladder Diagram, Logic, Timers, Counters, Case Studies related to use of PLC for Industrial Robotics applications.

Books:

1. M.P.Groover, Weiss, Nagel,Odrey, " Industrial Robotics-Technology, Programming and Applications", TMH Publications.
2. S.K.Saha, "Introduction to Robotics", 2nd edition, Tata McGrawHill Publication.
3. John J. Craig, "Introduction to Robotics: Mechanics and Control", 3rd edition, Pearson education.
4. Nagrath IJ and Gopal M. " Control System Engineering", Wiley Eastern Reprint
5. Ogata K. "Modern Control Engineering", Prentice Hall of India (PHI)
6. C. D. Johnson, "Process Control Instrumentation Technology", PHI.
7. W. Bolton, " Mechatronics:Electronic Control systems in Mechanical and Electrical Engineering",3rd Edition, Pearson Education.
8. Venkatesh, Rao, "Control Systems", Cengage Publication.
9. Garry Dunning, "Intro: Programmable Logic Controllers", Thomson Delmar Learning.
10. Dobot Magician Online Tutorials, https://www.dobot-robots.com/products/magician

24PEMME201A Programme Elective (A) Product Design for Manufacturing and Assembly

Teaching Scheme
Lecture : 3 Hrs/week

Examination Scheme
In semester : 50 marks
End semester : 50 marks
Credits : 3

Prerequisite:
- Manufacturing process, Machine shop,
- Machine Design I & II, CAMD,
- Mini / Final year B.E./B.Tech. Projects

Course Objectives:
1. To introduce the DFMA concepts general guidelines for selection of material and manufacturing processes.
2. To acquaint students with various design rules and recommendations for optimum design based on different manufacturing processes and material used to manufacture the parts.
3. To make students understand the design factors and processes along with customer desires for manufacturing.
4. To develop thinking in the mind of students about the process of cost saving by knowing methods to use DFMA concepts for avoiding scrap and minimizing reworks, design iterations between design and manufacturing / vendors.

Course Outcome:
After learning the course, the students should be able to –
1. Apply DFMA concepts to avoid scrap and minimize reworks, design iterations between design and manufacturing / vendors.
2. Identify the design factors to recommend material and manufacturing processes for product design.
3. Apply techniques of Design for Assembly for product design.
4. Identify factors affecting the environment while designing manufacturing and/or assembly processes.

Unit 1: Introduction to Product Design
Three Phases of Design Engineering Process: Conceptual, Embodiment & Detailed design.
Design approaches: Over the Wall, Concurrent engineering, System Engineering & DFMA, Three DFMA criteria for redesign of a product, DFMA case studies;
Classification and Selection: Manufacturing processes & materials for product design.

Unit 2: Design for Assembly (DFA)
Assembly process: Characteristics and applications, General taxonomies of assembly operation and systems, Design consideration and recommendation for Manual Assembly, DFA index;
Examples of common assembly and DFMA case studies;
G D & T Considerations for DFMA.

Unit 3: Design for Machining (DFM)
DFM-1: Process description, Typical characteristics and applications; Suitable materials; Dimensional factors and tolerances; Design recommendations: Design for Turning, Milling, Round-Holes Machining, Planning, Shaping and Slotting, Broaching, Grinding;
Design recommendations: Jigs & Fixtures for manufacturing and measurement parts.

Unit 4: Design for Forming and Joining Processes (DFM-2)
DFM-2: Process steps, Typical characteristics and applications; Defects; Suitable materials; *Design consideration and recommendations*: for selected process viz.Castings, Injection Molding, Forging, Sheet-metal stamping, Welding Extrusion and Powder Metal Processing.

Unit 5: Design for Additive Manufacturing and Environment (DFAM & E)
Design for Additive Manufacturing: Brief introduction to typical characteristics (w.r.to supports, overhangs, rounds etc.) and application; Design for AM to combine the functions of multiple parts into one;
Design for the Environment: Introduction, objectives, Design to minimize material usage, Design for Recyclability, Design for remanufacture, Design for energy efficiency, Design to regulations and standards, Design for sustainability and the environment.

Books:

1. G. Boothroyd, P. Dewhurst, W. A. Knight, Product Design for Manufacture and Assembly, CRC Press.
2. K. T. Ulrich and S. D. Eppinger, Product Design and Development, McGraw-Hill Higher Education.
3. Bralla, James G., Handbook of Product Design for Manufacturing, McGraw Hill.
4. G E Dieter, Engineering Design - A Material Processing Approach, McGraw Hill.
5. B. R. Fischer, Mechanical Tolerance stackup and analysis, CRC Press.
6. D E Whitney, Mechanical assemblies: their design, manufacture, and role in product development, Oxford Press.

References:

1. J. Lesko, (1999) Industrial Design, Materials and Manufacture Guide, John Willy and Sons
2. George E. Dieter and Linda C. Schmidt (2009), Engineering Design, Fourth edition, McGraw-Hill Companies, New York, USA
3. Geoffrey Boothroyd, Peter Dewhurst and Winston Knight (2002) Product Design for Manufacture and Assembly, Third Edition, CRC Press, Taylor & Francis, Florida, USA
4. O. Molloy, S. Tilley and E.A. Warman (1998) Design for Manufacturing and assembly, First Edition, Chapman &Hall, London, UK.
5. D. E. Whitney, (2004) Mechanical Assemblies: Their Design, Manufacture, and Role in Product Development, Oxford University Press, New York
6. A.K. Chitale and R.C. Gupta, (1999) Product design and Manufacturing, Prentice Hall of India, New Delhi.
7. James G. Bralla (1998) Design for Manufacturability Handbook, Second Edition, McGraw-Hill Companies, New York, USA

8. Geoffrey Boothroyd (2005) Assembly Automation and Product Design, second edition, CRC Press, Taylor & Francis, Florida, USA
9. G. Q. Huang (1996) Design for X, Concurrent Engineering Imperatives, First Edition, Chapman &Hall, London, UK.

References at nptel.ac.in

1. DFMA : http://nptel.ac.in/courses/107103012/
2. DFM : http://nptel.ac.in/courses/112101005/1

24PEMME201B Programme Elective (B) Manufacturing and Mechanics of Composite Materials

Teaching Scheme
Lecture: 3 Hrs/week

Examination Scheme
In semester: 50 marks
End semester: 50 marks
Credits: 3

Prerequisites:
1. Engineering Mechanics
2. Strength of Materials
3. Engineering Metallurgy

Course Objectives:
1. To understand a perspective utilization and processing of composite materials
2. To analyze the lamina of composite material at the micro and macro level
3. To analyze the laminated composite material at the macro level
4. To understand testing methods of composite materials to evaluate mechanical properties

Course Outcomes:
Upon completion of this course, the student will be able to:
1. Define need, utilization of class of composite material, its constitution, list its application fields, and demonstrate the various fabrication process
2. Micro and macro-mechanical analysis of the composite material at the lamina level
3. Analyze the laminated composite material at a macro level using classical lamination theory
4. Define testing methods of composite materials to evaluate performance

Unit 1. Introduction to composite:
Introduction to advanced materials and types, Definition, General Characteristics, Applications, Fibers, Types of fibers, Mechanical Properties of fibers; Matrix, Types of the matrix, Polymer Matrix- Thermoset and Thermoplastic, Fillers/Additives/Modifiers of Fiber Reinforced Composites

Unit 2. Manufacturing of composites:
The fabrication process for thermoset and thermoplastic PMC, open mould process as hand layup techniques; structural laminate bag molding, production procedures for bag molding; filament winding, and Closed mould process as pultrusion, performing, thermo-forming, injection molding, blow molding, Process parameters. Manufacturing of Metal matrix composites – Stir casting, Infiltration, Manufacturing of Ceramic matrix composites - chemical vapor deposition, Liquid Silicon Infiltration, Manufacturing of Carbon-Carbon composites, and nanocomposites.

Unit 3. Micro and Macro Mechanical analysis of Lamina:
Introduction, Volume and mass fraction, density, void content, evaluation of elastic moduli, the ultimate strength of unidirectional lamina

Review and definition of stress, strain, and Elastic Moduli, Hooke's Law for different types of materials, Hook's law for 2D unidirectional and angular lamina, engineering constants of an angle lamina, Strength failure theories of an angle lamina

Unit 4. Macro Mechanical analysis of Laminate:
Introduction to Laminate Code, Strain-displacement relations, Stress-strain relation for a laminate, force and moment resultants related to midplane strains and curvatures, In-Plane engineering constants of a laminate, Flexural engineering constants of a laminate.

Unit 5. Testing of Composites:
Societies for Testing Standards, Background to Mechanical Testing of Composites, Test Method and analysis of Tensile Properties, Compressive Properties, Flexural Properties, In-Plane Shear Properties, Inter-laminar Shear Strength properties, Impact Properties.

Books:

1. Autar K. Kaw, "Mechanics of Composite Materials", CRC Press, Taylor & Francis Group, 2012.
2. Isaac M. Daniels, Ori Ishai, "Engineering Mechanics of Composite Materials", Oxford University Press, 2010
3. Madhujit Mukhopadhyay, "Mechanics of Composite Materials and Structures", University Press, 2004.
4. Robert M. Jones, "Mechanics of Composite Materials" 2nd Edition, CRC Press 1998

24PCMME201L Advanced Mechanical Vibrations Lab

Teaching Scheme	**Examination Scheme**
Practical: 2 Hrs/week	In semester: 25 marks
Tutorials: - Hr/Week	Oral: 25 marks

Course Objectives:

1. To conduct experimental modal analysis to determine natural frequencies and mode shapes
2. To carry out computational vibration analysis using MatLab to analyze a multi-degree freedom system.
3. To diagnose fault (imbalance) and to correct it using computerised wheel balancing machine
4. To determine of natural frequencies and mode shapes using multi degree of freedom system using suitable numerical methods:

Course Outcomes: Upon completion of this course, the student will be able to,

1. conduct experimental modal analysis to determine natural frequencies and mode shapes
2. carry out computational vibration analysis using MatLab to analyze a multi-degree freedom system.
3. diagnose fault (imbalance) and to correct it using computerised wheel balancing machine
4. determine of natural frequencies and mode shapes using multi degree of freedom system using suitable numerical methods:

Laboratory Experiments/Assignments:

1. **Experimental Vibration Analysis**
   a. Selection and application of various vibration measuring devices and transducers.
   b. Experimental modal analysis on Beam to determine natural frequencies and mode shapes
   c. Experimental modal analysis on Beam to determine damping factor
2. **Computational Vibration Analysis**
   a. Solution of a problem on multi-degree freedom system in MATLAB using Simulink and modal analysis method and then compare results of the two using overlay plots
   b. Vibration analysis of a mechanical system using numerical integration method such as Runge-Kutta / Finite difference Method using MATLAB
3. **Fault Diagnosis**
   a. Fault diagnosis in rotating mechanical system. Detection of unbalance and misalignment in shaft rotor using computerised wheel balancing machine
4. **Assignments**
   a. Derive EoM for any two of the following cases
      (1) Transverse vibrations of String,
      (2) Longitudinal vibration of Rods,
      (3) Torsional vibrations of Shaft,
      (4) Lateral vibrations of cantilever beams

b. Determination of natural frequencies and mode shapes using multi degree of freedom system using any three of the following methods:
   (1) Rayleigh's Method
   (2) Methods of Matrix iterations
   (3) Jacobi diagonalization method
   (4) Holzer's Method
   (5) Dunkerley's method.

24PCMME204L Industrial Robotics Lab

Teaching Scheme
Practical: 2 Hrs/week

Examination Scheme
In semester: 25 Marks
Oral: 25 Marks

Course Objectives:
To familiarize the students with

1. Basics of robots, robot subsystems, robot kinematics and Machine Vision
2. Control system, Control system classifications and Controller actions
3. Industrial applications of robots and Controllers.

Course Outcomes: Upon completion of this course, the student will be able to,

1. Compile the various types of sensors, actuators used for industrial robotics, identify various types of robot configurations and work envelopes.
2. Evaluate and Perform Forward and Inverse Kinematic analysis of a given robot manipulator.
3. Integrate different types of Sensors, actuators and control the basic robotic motion.
4. Demonstrate the various capabilities of Industrial Collaborative Robot- DOBOT MAGICIAN with Machine Vision Applications.

Laboratory Experiments/Assignments:

1. Study the components and various configurations of an industrial robot (PUMA, KUKA, FANUC, MTAB , UR and DOBOT MAGICIAN) and it's D-H Parameters.
2. Integration of assorted sensors (IR, Potentiometer, Strain gauges etc.) and actuators with any real world system (Car Engine Management, DOBOT Robot etc.) using arduino uno board and sensors.
3. Experimental Analysis and verification of various static characteristics of Temp. sensor.
4. Forward kinematics and validation using suitable software (Robo Analyser/ MatLab or any software (Robo Analyser/ MatLab or any other free software tool).
5. Inverse kinematics of an industrial robot and validation using any open source software (Robo Analyser/ MatLab or any other free software tool).
6. Industrial visit to any Robotic assembly line or Robot assisted manufacturing plant.
7. Collaborative Robot- Dobot Magician Tutorials- Template Matching,3-D Printing, Color Recognition, Laser Engraving, Write and Draw, Pick and Place, Faulty item detection, Gesture Control etc.
8. Tuning of PID Controller for suitable industrial application.
9. PLC Ladder Diagram: Logic Gates, Timers, Counter, Latch, Case Studies.

24PEMME201L Programme Elective Lab (A) Product Design for Manufacturing and Assembly Lab

Teaching Scheme
Practical: 2 Hrs/week

Examination Scheme
In semester: 25 Marks
Oral: 25 Marks

Course Objectives:

To familiarize the students with

1. The various design rules and recommendations for optimum design based on different standard process for selection of material and manufacturing processes.
2. To make students understand the process of performing Functional Analysis to develop Assembly Metrics for a product (design)
3. To develop thinking in the mind of students about the process of cost saving by knowing methods to use DFMA concepts for avoiding scrap and minimizing reworks, design iterations between design and manufacturing / vendors.
4. To develop students to identify factors affecting the environment while designing manufacturing and/or assembly processes.

Course Outcomes: Upon completion of this course, the student will be able to –

1. Select a suitable material, shape and manufacturing process for defined part
2. Perform Functional Analysis to develop Assembly Metrics for a product (design)
3. Analyse the part-drawing (GD&T) w.r.to assembly and manufacturing process perspective.
4. Identify factors affecting the environment while designing manufacturing and/or assembly processes.

Lab work to be Accomplished:

Assignment 1: Material and Manufacturing Process Selection

- Select a suitable material, shape and manufacturing process for a given product *[Only for example and not limited to viz. Bicycle forks, Flywheel, Pressure vessel, Fan blades]*.
- Explain with justification the function, constraint, objective, free variable clearly and select material along with the manufacturing process.

Assignment 2: DFA by doing 'Functional Analysis' and developing 'Assembly Metrics'

- Select an assembly of any suitable product and …
  - analyse product assembly w.r.to to the DFA guidelines,
  - estimating DFA indices
  - report opportunities for assembly improvement
- Students are suggested to follow the standard template to submit this assignment (report).

Assignment 3: Analyse the part-drawing and explain its (GD&T) w.r.to Assembly and Manufacturing process perspective

- Select any suitable engineering part/component drawing.

- list the standard types of Form Tolerances shown in the selected drawing.
- explain which type of tolerancing method is adopted.
- explain how many types of Datum – planes are shown in the drawing and show them.
- *Note:- Students are the attached template for submission of this assignment.*

Assignment 4: Design for Manufacturing

- Select any suitable product part / engineering component and …
  - Carefully select part features and identify standard DFM guidelines, which you think is applicable for the .
  - Refer to Ashby's manufacturing processes selection guidelines for designing/recommending manufacturing processes.
  - *Note:- Students are free to refer to any reference material available [viz. books, research papers, case studies available on the internet to study for completing this assignment].*

Assignment 5: Design for Environment

- Carefully select product / component for study ….
- Explained process (and technical reasoning)for redefining product / its feature design / process specifications(s), and explain before and after points in tabulated form which you think is applicable w.r.to 'Design for Environment' reduce environmental impact (at product design stage) w.r.to any two aspects…

  1. Design to minimize material usage, 2. Design for disassembly, 3. Design for recycling, 4. Design for remanufacturing, 5. Design to minimize hazardous materials, 6. Design for energy efficiency, 7. Design to regulations and standards

References

1. Material Selection in Mechanical Design, Michael F. Ashby, 3rd Edition, Elsevier Publication.
2. G Dieter, Engineering Design - a materials and processing approach, McGraw Hill, NY, 2000.
3. ASME Y14.5-2009 standard.
4. Learning material on GD&T, CIL, India.
5. Bryan R. Fischer, 2004, Mechanical Tolerance Stackup and Analysis, Marcel Dekker, Inc., New York, Basel.
6. Learning material for completing these assignments…
   https://classroom.google.com/c/Mjc4MTMyMTE3NDZa/a/MzU0NTY3OTg0MDNa/details

24PEMME201L Programme Elective Lab (B) Manufacturing and Mechanics of Composite Materials Lab

Teaching Scheme
Practical: 2 Hrs/week

Examination Scheme
In semester: 25 marks
End semester: 25 marks
Credits: 1

Course Objectives:

1 Understand a perspective on the utilization of composite materials in structure
2 Analyze the composite material at the lamina level.
3 Analyze the laminated composite material
4 Understand methods of composite materials testing

Course Outcomes: Upon completion of this course, the student will be able to:

1. Analyse lamina at micro-mechanical and macro-mechanical levels of polymer matrix composites.
2. Analyse laminated composites using classical lamination theory.
3. Fabricate the unidirectional composite laminate using a compression moulding process.
4. Test and evaluate mechanical properties of polymer composites as per ASTM standards

Lab work to be Accomplished:

1. Fabricate uni/multi-directional fiber-reinforced polymer matrix composites using compression molding with different volume fractions of fiber.
2. Write a program to evaluate the effect of the content of fiber reinforcement on the elastic and strength properties of a composite lamina.
3. Write a program to evaluate the synergy of the orientation of fiber on elastic properties of a composite angular lamina.
4. Write a program to find stresses and strains (global and local) of the angular lamina and then failure analysis using different failure theories.
5. Write a Program to evaluate the elastic properties of composite laminate for different stacking sequences and orientations.
6. Perform tensile testing of the composite lamina to determine tensile strength, tensile modulus, and elongation at break as per ASTM 3039 standard.
7. Perform flexural testing of the composite lamina to determine flexural strength and flexural modulus as per ASTM D790 standard.
8. Perform Izod/Charpy impact test of composite lamina to determine impact strength as per ASTM D256 standard.

Book:

1. Fiber-Reinforced Composites: Materials, Manufacturing, and Design, Third Edition (Mechanical Engineering). by P.K. Mallick | 19 November 2007