LENDI INSTITUTE OF ENGINEERING AND TECHNOLOGY
An Autonomous Institution
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DEPARTMENT OF MECHANICALENGINEERING

M.Tech (Machine Design) Course Structure–R22

(w.e.f the academic year 2022-23)

I Year-I Semester

S.No	Course Code	Subject Name	L	P	Credits
1	ME-MD1101	Advanced Mechanics of Solids	3	0	3
2	ME-MD1102	Geometric Modeling	3	0	3
3	ME-MD1103	Tribology	3	0	3
4	ME-MD1104	**Elective–I**	3	0	3
	ME-MD1104.1	1.Design of Modern Vehicle Systems			
	ME-MD1104.2	2.Product Design and Development			
	ME-MD1104.3	3. Advanced Mechanisms			
	ME-MD1104.4	4.Non-Destructive Evaluation			
	ME-MD1104.5	5.MOOC'S*			
5	ME-MD1105	**Elective–II**	3	0	3
	ME-MD1105.1	1.Fracture Mechanics			
	ME-MD1105.2	2.Design for Manufacturing & Assembly			
	ME-MD1105.3	3.Robotics			
	ME-MD1105.4	4.Advanced Machine Design			
	ME-MD1105.5	5.MOOC'S*			
6	MEMD1106	Machine Dynamics Lab	0	4	2
7	MEMD1107	Advanced Computer aided modelling lab	0	4	2
		Total	**15**	**8**	**19**

I Year–II Semester

S.No	Course Code	Subject Name	L	P	Credits
1	ME-MD1201	Experimental Stress Analysis	3	0	3
2	ME-MD1202	Advanced Finite Element Methods	3	0	3
3	ME-MD1203	Mechanical Vibrations	3	0	3
4	ME-MD1204	**Elective–III**	3	0	3
	ME-MD1204.1	1.Material selection in mechanical design			
	ME-MD1204.2	2.Condition Monitoring and Signal Analysis			
	ME-MD1204.3	3.Vehicle dynamics			
	ME-MD1204.4	4.Optimization and reliability			
	ME-MD1204.5	5.MOOC'S*			
5	ME-MD1205	**Elective-IV**	3	0	3
	ME-MD1205.1	1.PressureVesselDesign			
	ME-MD1205.2	2.Mechanics of Composite Materials			
	ME-MD1205.3	3.Theory of Plasticity			
	ME-MD1205.4	4.Design with advanced materials			
	ME-MD1205.5	5.MOOC'S*			
6	MEMD1206	Computational Mathematics Lab	0	4	2
7	MEMD1207	Advanced Computer aided analysis lab	0	4	2
		Total	**15**	**8**	**19**

II Year–I Semester

S.No	Course Code	Subject Name	L	P	Credits
1	ME-MD2101	Seminar-I	0	0	2
2	ME-MD2102	Project Stage-I	0	20	10
3	ME-MD2103	English for research paper writing	2	0	0
4	ME-MD2104	Research Methodology and IPR	2	0	2
		Total	**4**	**20**	**14**

II Year–II Semester

S.No	Course Code	Subject Name	L	P	Credits
1	ME-MD2201	Project Stage-II	0	32	16
		Total	**0**	**32**	**16**

** Select subject from mechanical discipline as per the guidelines from the BOS Chairman.*

I Year-I Semester

Subject Code	Subject Name	L	P	Credits
ME-MD1101	Advanced Mechanics of Solids	3	0	3

Course Objectives:

The objectives of the course are to

- Introduce the concepts of different stresses, strains and their relationships.
- Understand the principal stresses and components of stress on different planes and maximum shear force and bending moment of different beams under different loading conditions.
- Determine bending stress and shear stress distribution of various cross sections of beams and to predict the maximum slope and deflection of beams.
- Impart knowledge on strain energy due to axial, bending, and torsional loading.
- Exposure to the concepts of the stresses and deformations of the springs.

Course Outcomes:

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

1. ***apply*** the concepts of stress and strain to machine numbers.(L3)
2. ***analyze*** modes of failure of materials.(L4)
3. ***determine*** the bending stresses of non-symmetrical bending of beams.(L3)
4. ***calculate*** the torsion in machine members.(L3)
5. ***analyze*** the contact stresses in the different members.(L4)

Unit I

Theories of stress and strain, Definition of stress at a point, stress notation, principal stresses, other properties, differential equations of motion of a deformable body, deformation of a deformable body, strain theory, principal strains, strain of a volume element, small displacement theory.

Stress–strain temperature relations: Elastic and non-elastic response of a solid, first law of thermodynamics, Hooke's Law, Anisotropic elasticity, Hooke's Law, Isotropic elasticity, initiation of Yield, Yield criteria.

Application: beams and structures

Learning outcomes:

At the end of the unit, student will be able to

- ***understand*** the stresses and deformations due to axial loads in simple members.(L2)
- ***apply*** the principal stresses in biaxial state of loading.(L3)

Unit II

Failure criteria: Modes of failure, Failure criteria, Excessive deflections, Yield initiation, fracture, Progressive fracture,(High Cycle fatigue for number of cycles $N>10^6$,buckling.

Application of energy methods: Elastic deflections and statically indeterminate members and structures: Principle of stationary potential energy, Castiglione's the orem on deflections, Castiglione's theorem on deflections for linear load deflection relations, deflections of statically determinate structures.

Application: analysis of failure of simple mechanical machine elements like rivets, bolts etc.

Learning outcomes:

At the end of the unit, student will be able to

- ***explain*** the various modes of failures in members.(L2)

- ***apply*** Castiglione's theorem on deflections for linear load deflection relations(L3)

Unit III

Unsymmetrical bending: Bending stresses in Beams subjected to Nonsymmetrical bending; Deflection of straight beams due to non symmetrical bending.

Curved beam theory: Winkler Bach formula for circumferential stress – Limitations – Correction factors –Radial stress in curved beams – closed ring subjected to concentrated and uniform loads-stresses in chain links.

Application: analysis of structures and Automobile Chassis.

Learning outcomes:

At the end of the unit, student will be able to

- ***determine*** the bending stresses in Beams subjected to Non symmetrical bending.(L3)
- ***calculate*** Radial stress in curved beams.(L3)

Unit IV

Torsion: Linear elastic solution; Prandtl elastic membrane (Soap-Film) Analogy; Narrow rectangular cross Section; Hollow thin wall torsion members, Multiply connected Cross Section.

Application: twisting moment for wheel and hub of a automobile**.**

Learning outcomes:

At the end of the unit, student will be able to

- ***determine*** the torsion in Narrow rectangular cross Section.(L3)
- ***determine*** the torsion in Multiply connected Cross Section L3)

Unit-V

Contact stresses: Introduction; problem of determining contact stresses; Assumptions on which a solution for contact stresses is based; Expressions for principal stresses; Method of computing contact stresses; Deflection of bodies in point contact; Stresses for two bodies in contact over narrow rectangular area (Line contact), Loads normal to area; Stresses for two bodies inline contact, Normal and Tangent to contact area.

Learning outcomes:

At the end of the unit, student will be able to

- ***develop*** the Expressions for principal stresses.(L3)
- ***determine*** the Stresses for two bodies in contact over narrow rectangular area(L3)

Textbooks

1. Advanced Mechanics of materials by Boresi& Sidebottom-Wiely International.
2. Advanced Mechanics of Solids, L.S Srinath

References

1. Advanced strength of materials by Den HortogJ.P.
2. Theory of plates–Timoshenko.
3. Strength of materials & Theory of structures (VolI&II) by B.CPunmia
4. Strength of materials by Sadhusingh

Subject Code	Subject Name	L	P	Credits
ME-MD1102	Geometric Modeling	3	0	3

Course Objective:

The objectives of the course are to

1. ***understand*** the Explicit and implicit equations used in geometric Modeling
2. ***knowledge*** on generation of composite pc curves.
3. ***understan*** the concept of B-Spline basis and its equations,
4. ***generate*** B-Spline Curves

Course outcomes:

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

1. ***understand*** the parametric equations of different curves.(L2)
2. ***analyze*** the Graphic construction and interpretation of cubic spline.(L4)
3. ***analyze*** the B-spline curves equations.(L4)
4. ***develop*** different types of geometric surfaces.(L2)
5. ***analyze*** the solids of the geometry.(L4)

Unit–I

Cubic spline –I

Definition, Explicit and implicit equations, parametric equations, Algebraic and geometric form of cubic spline, Hermite cubic spline, tangent vectors, parametric space of a curve, blending functions.

Learning Outcomes:

After completion of this unit the students will be able to

1. ***understand*** the Explicit and implicit equations.(L2)
2. ***explain*** the blending functions.(L2)

Unit-II

Cubic Splines-II

Four point form, reparametrization, truncating and sub dividing of curves. Graphic construction and interpretation, composite pc curves.

Bezier Curves

Bernstein basis, equations of Bezier curves, properties, derivatives.

Learning Outcomes:

After completion of this unit the students will be able to

1. ***analyze*** the Graphic construction and interpretation of Bezier Curves.(L4)

Unit-III

B-Spline Curves

B-Spline basis, equations, knot vectors, properties, and derivatives.

Learning Outcomes:

After completion of this unit the students will be able to

1. ***analyze*** the B-spline curves.(L4)
2. ***apply*** knot vectors in generation of B-Spline Curves.(L3)

Unit–IV

Surfaces

Bi cubic surfaces, Coon's surfaces, Bezier surfaces, B-Spline surfaces, surfaces of revolutions, Sweep surfaces, ruled surfaces, tabulated cylinder, bilinear surfaces, Gaussian curvature.

Learning Outcomes

After completion of this unit the students will be able to

1.***analyze*** the Bi cubic, Bezier B-Spline surfaces.(L4)

2.***develop*** bilinear surfaces.(L3)

Unit–V

Solids

Tri cubic solid, Algebraic and geometric form.

Solid modeling concepts

Wire frames, Boundary representation, Half space modeling, spatial cell, cell decomposition, classification problem.

Learning Outcomes

After completion of this unit the students will be able to

1.***develop*** the solid models.(L4)

2.***classify*** the problems of Solid modeling.(L2)

Text Books

1. Elements of Computer Graphics by Roger & Adams Tata Mc Graw Hill.
2. Geometric Modeling by Micheal E.Mortenson, Mc Graw Hill Publishers

References:

1. Computer Aided Design and Manufacturing, K. Lalit Narayan, K.Mallikarjuna Rao, MMMSarcar, PHI Publishers

Code	Subject Name	L	T	P	C
ME-MD1103	Tribology	3	0	0	3

Course Objective:

The objectives of the course are to

- To know the contact surface effects of bearings
- To know the seals and analysis of failure

Course Outcomes:

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

- ***understand*** the contact surfaces & Effects of lubricants(L2)
- ***explain*** the selection of Rolling contact bearings(L2)
- ***illustrate*** the design procedure of Hydrostatic Bearings(L2)
- ***develop*** optimum bearing with maximum load capacity (L3)
- ***analyze*** Failure of Tribological components (L4)

Unit–I

Introduction: Nature of surfaces and contact-Surface topography-friction and wear mechanisms, wear maps, effect of lubricants-methods of fluid film formation.

Lubrication: Choice of lubricants, types of oil, Grease and solid lubricants- additives-lubrication systems and their selection.

Learning outcomes:

After completion of this unit, students will be able to

- ***explain*** contact surfaces & Effects of lubricants**(L2)**
- ***illustrate*** Analyze on Bearing still it failure**(L2)**

Application: Automobile &Machine components

Unit–II

Selection of rolling element bearings: Nominal life, static and dynamic capacity-Equivalent load, probabilities of survival- cubic mean load- bearing mounting details, pre loading of bearings, conditioning monitoring using shock pulse method.

Application: Automobile & Machine components

Learning outcomes:

After completion of this unit, students will be able to

- ***design*** Rolling contact bearings (L3)

Unit–III

Hydrostatic Bearings: Thrust bearings – pad coefficients- restriction- optimum film thickness-journal bearings – design procedure –Aerostatic bearings; Thrust bearings and Journal bearings –design procedure.

Learning outcomes:

After completion of this unit, students will be able to

- ***understand*** the working of Hydro static Bearings (L2)

Application: Machine components

Unit–IV

Hydrodynamic bearings: Fundamentals of fluid formation – Reynold's equation; Hydro dynamic journal bearings– Sommerfield number- performance parameters–optimum bearing with maximum load capacity – Friction – Heat generated and Heat dissipated. Hydrodynamic thrust bearings; Raimondi and Boyd solution for hydrodynamic thrust bearings- fixed tilting pads, single and multiple pad bearings-optimum condition with largest minimum film thickness.

Application: Automobile& Machine components

Learning outcomes:

After completion of this unit, students will be able to

- ***understand*** working of Hydro dynamic Bearings (L2)

Unit–V

Seals: different type-mechanical seals, lip seals, packed glands, soft piston seals, Mechanical piston rod packing, labyrinth seals and throttling bushes, oil flinger rings and drain grooves–Selection of mechanical seals.

Failure of Tribological components: Failure analysis of plain bearings, rolling bearings, gears and seals, wear analysis using soap and Ferro graphy.

Dry rubbing Bearings: porous metal bearings and oscillatory journal bearings–qualitative approach only.

Application: Automobile& Machine components, Construction& Material optimization on Mechanical components

Learning outcomes:

After completion of this unit, students will be able to

- ***prepare*** Hydro dynamic Bearings(L2)

Text Books

1. Rowe WW& O'Dionoghue, "Hydro static and Hybrid bearing design "Butter worths& Co. Publishers Ltd.
2. Collacott R.A, "Mechanical Fault diagnosis and condition monitoring", Chapman and Hall, London.
3. Bernard J.Hamrock, "Fundamentals of fluid film lubricant", McGraw- Hill Co.

References

1. Neale MJ,(Editor)"Tribology hand Book" Neumann Butterworths.
2. Connor and Boyd JJO (Editors)"Standard hand book of lubrication engineers" ASLE, McGraw Hill Book & Co.
3. ShigleyJ, E Charles, "Mechanical Engineering Design" ,McGraw Hill Co.,

Subject Code	Subject Name	L	P	Credits
ME-MD1104.1	Design of Modern Vehicle Systems **(Elective-I)**	3	0	3

Course Objectives:

The objectives of the course are to

1. Develop the conceptual design of automobiles
2. Develop knowledge on Electric vehicles(EV)
3. Analyze the design of hybrid vehicles
4. understand the Working Principle and Design of drones
5. Awareness on safety practices.

Course outcomes:

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

1. ***develop*** Conceptual design of automobiles.(L3)
2. ***apply*** Hybrid Vehicle principles in design of EV.(L3)
3. ***apply*** Hybrid design philosophy for EV.(L3)
4. ***apply*** Working Principles in Design of Drones.(L3)
5. ***summarize*** the Safety aspects of automobiles.(L2)

UNIT I

Conceptual design of automobiles: body shape definition based on aero dynamic structure safety, sub - systems integration considerations, road load analysis, transmission of road loads to structure. Detail design of structural elements, load analysis for different vehicles, safety consideration, design for bending, torsion conditions, criteria for toppling, based on cornering loads.

Learning Outcomes:

After completion of this unit the students will be able to

1. ***understand*** sub systems of automobiles.(L2)
2. ***apply*** the torsion conditions in design of automobiles.(L3)

UNIT II

Basics of Electric vehicles (EV), Review of existing design of EV, EV design, Performance, Operation and charging.

Hybrid Vehicles Principles-serial, parallel, electrical, hydraulic

Learning Outcomes:

After completion of this unit the students will be able to

1. ***explain*** the principles in design of EV.(L2)
2. ***understand*** operation procedure of EV.(L2)

UNIT III

Definition of hybridness, Hybrid design philosophy, Hybridness: parallel hybrid, series, mixed and range extender (plug-in) hybrids , Range extender , Optimization and hybridness, Battery power and electric motor power

Learning Outcomes:
After completion of this unit the students will be able to
1.***explain*** the methods to utilize Battery power and electric motor power.(L2)
2.***apply*** optimization concepts in Hybrid vehicle design.(L3)

UNIT IV
Introduction to UAVs/Drones, Drone Applications, Working Principle and Design, Inertial Measurement Unit, Sensors and Calibration, PID - Implementation and Tuning, Flight controller, Remote Controller, Quad copter dynamics

Learning Outcomes:
After completion of this unit the students will be able to
1.***explain*** the Working Principles of drones.(L2)
2.***understand*** Quad copter dynamics.(L2)

UNIT V
Safety aspects of automobiles, devices, energy absorbing systems, crashworthiness, legislation relating to safety, vehicle performance requirements, sub systems packaging and verification of vehicle performance through testing (lab, field testing).

Learning Outcomes:
After completion of this unit the students will be able to
1.***understand*** the legislation relating to safety of vehicles.(L2)
2.***elucidite*** the vehicle performance requirements.(L2)

TEXTBOOKS

1 Donalde. Males, Fundamentals of automobile body structure design(R-394),SAE
2 W.F.Milliker,D.L.Milliker,MauriceOlly,Chassisdesign:principlesananalysis(R-206)SAE
3 J.H Smith, Introduction to Modern Vehicle Design, Butterworth-Heinemann

Subject Code	Subject Name	L	P	Credits
ME-MD1104.2	Product Design and development **(Elective-I)**	3	0	3

Course Objective:

The objectives of the course are to

- ***understand*** the process of product development.
- ***explain*** the concept generation for new products.
- ***awareness*** on legal issues in design of the products.
- ***develop*** the concepts of project finance and management.

Course outcomes:

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

1. ***illustrate*** the product development process. **(Level 2)**
2. ***explain*** methodical approach to the product design to satisfy customer needs. **(Level 2)**
3. ***develop*** the concepts of design for manufacturing(L3)
4. ***apply*** ergonomics and Quality aspects in designing the industrial products **(Level 3)**
5. ***understand*** the design protection methods, Intellectual Property and management of product development projects**(Level 2)**

UNIT-I

Product Development Process

Background for design, , human factors in design, applied ergonomics, product development processes and organization, identifying customer needs, establishing product specifications, concept generation and selecting product architecture.

Learning Outcomes:

After completion of this unit the students will be able to

1.**explain** the ways to identifying customer needs**(L 2)**

2**. elucidate** the procedure to establish product specifications(L2)

Unit-II

Product Design Methods

Generating concepts, selection of a concept, Testing of concept, product architecture, Creative and rational clarifying objectives- the objective trees methods, establishing functions – the function analysis methods, setting requirements specification methods determining characteristics – the QFD method, generating alternatives-the morphological chart method, evaluating alternatives-the weighted objectives methods, improving details-the value engineering method and design strategies.

Learning Outcomes:

After completion of this unit the students will be able to

1. ***explain*** the methods to generate alternatives for Product Design**(L 2)**
2. ***understand*** the product architecture**(L 2)**

UNIT –III

Design for Manufacture
Estimating manufacturing costs, reducing component, assembly and support cost design for assembly, design for disassembly, design for environment, design for graphics and packaging, effective prototyping – principle and planning.

Learning Outcomes:
After completion of this unit the students will be able to
1. ***summarize*** the elements of manufacturing costs**(L 2)**
2. ***outline*** the environment issues in Design for Manufacturing**(L 2)**

UNIT –IV

Industrial Design
Industrial Design - Ergonomic needs, Aesthetic needs, impact, accessing the quality, steps involved in Industrial design process, Management of Technology & user driven products.

Learning Outcomes:
After completion of this unit the students will be able to
1**.** ***explain*** the steps involved in Industrial design process**(L2)**
2. ***apply*** technological developments in Product Design**(L3)**

UNIT – V

Patents, Product Development & Project Management
Legal issues in product design, trademarks, trade-secret, copy rights, patents – types, steps for disclosure, design resources, economics – quantitative & qualitative analysis, management of product development projects, Design Structure Matrix, Gantt Chart, Project schedule, budget, risk plan, accelerating project, execution, assessing and correction, Intellectual property rights.

Learning Outcomes:
After completion of this unit the students will be able to
1. ***understand*** Legal issues in product design **(L2)**
2. ***explain*** project planning, scheduling and control procedure **(L2)**

Text Books
1. Product Design & Development - Karl. T. Ulrich and Steven D. Eppinger – TMH, Delhi.
2. Product Design – Kevin Otto and Kristin wood - Pearson Education.

References
1 Product Design: Creativity, Concepts and Usability – Kumar – PHI, Delhi .
Product Design and Manufacturing – Chitale & Gupta – PHI, Delhi.

Subject Code	Subject Name	L	P	Credits
ME-MD1104.3	Advanced Mechanisms **(Elective–I)**	3	0	3

Course Objectives:

The objectives of the course are to

- Introduce the concepts of Elements of Mechanisms, Mobility Criterion for Planar mechanisms.
- Discuss the application of the Inflection circle to kinematic analysis.
- Understand relative motion the output and input link sand determination of the output angular acceleration and its rate of change.
- analyze the Direct and Inverse kinematic analysis of Serial manipulators.

Course Outcomes:

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

1. ***apply*** the Mobility Criterion for Planar mechanisms and manipulators.(L3)
2. ***analyze*** the Advanced Kinematics of plane motion (L4)
3. ***apply*** the synthesis-Graphical Methods for Guiding a body (L3)
4. ***analyze*** Four-bar Mechanisms for specified instantaneous condition(L4)
5. ***analyze*** the Direct and Inverse kinematics of Articulated, spherical & industrial robot manipulators (L4)

Unit-I

Introduction: Elements of Mechanisms; Mobility Criterion for Planar mechanisms and manipulators; Mobility Criterion for spatial mechanisms and manipulators. Spherical mechanisms-spherical trigonometry.

Learning outcomes:

At the end of the unit, student will be able to

- ***understand*** the principles of Mechanisms.(L2)
- ***explain*** the Spherical mechanisms.(L2)

Unit–II

Advanced Kinematics of plane motion- I: The Inflection circle; Euler – Savary Equation; Analytical and graphical determination of d_i; Bobillier's Construction; Collineastion axis;Hartmann's Construction; Inflection circle for the relative motion of two moving planes; Application of the Inflection circle to kinematic analysis.

Advanced Kinematics of plane motion - II: Polode curvature; Hall's Equation; Polode curvature in the four bar mechanism; coupler motion; relative motion of the output and input links; Determination of the output angular acceleration and its Rate of change; Freudenstein's collineation –axis theorem; Carter –Hall circle; The circling – point curve for the Couplera four bar mechanism.

Learning outcomes:

At the end of the unit, student will be able to

- ***apply*** the Inflection circle to kinematic analysis.(L3)
- ***determine*** the output angular acceleration and its Rate of change(L3)

Unit–III

IntroductiontoSynthesis-GraphicalMethods-I: TheFourbarlinkage;Guidingabodythrough Two distinct positions; Guiding a body through Three distinct positions; The Rotocentertriangle;GuidingabodythroughFourdistinctpositions;Burmester'scurve.

Introduction to Synthesis-Graphical Methods - II: Function generation- General discussion; Function generation: Relative–rotocenter method, Overlay's method, Function generation-Velocity – pole method; Path generation: Hrones's and Nelson's motion Atlas, Roberts's theorem.

Learning outcomes:

At the end of the unit, student will be able to

- ***apply*** the synthesis methods for guiding a body(L3)

Unit–IV

Introduction to Synthesis - Analytical Methods: Function Generation: Freudenstien's equation, Precision point approximation, Precision – derivative approximation; Path Generation: Synthesis of Four-bar Mechanisms for specified instantaneous condition; Method of components; Synthesis of Four-bar Mechanisms for prescribed extreme values of the angular velocity of driven link; Method of components.

Learning outcomes:

At the end of the unit, student will be able to

- ***apply*** principles of Four-bar Mechanisms for specified instantaneous condition (L3)

Unit–V

Manipulator kinematics: D-H transformation matrix ; Direct and Inverse kinematic analysis of Serial manipulators: Articulated, spherical & industrial robot manipulators-PUMA, SCARA, STANFORD ARM, MICROBOT.

Learning outcomes:

At the end of the unit, student will be able to

- ***apply*** Manipulator kinematics in design of industrial robots(L3)
- ***apply*** D-H transformation matrix for kinematic analysis(L3)

Text Books

1. Jeremy Hirschhorn, Kinematics and Dynamics of plane mechanisms, McGraw-Hill.
2. L.Sciavicco and B.Siciliano, Modelling and control of Robot manipulators, Second edition, Springer-Verlag,London.
3. Amitabh Ghosh and Ashok Kumar Mallik, Theory of Mechanisms and Machines.E.W.P.Publishers.

Reference Books

1. Allen S.HallJr., Kinematics and Linkage Design, PHI.
2. J.EShigley and J.J.Uicker Jr.,Theory of Machines and Mechanisms, McGraw-Hill,.

Joseph Duffy, Analysis of mechanisms and Robot manipulators, Edward Arnold.

Subject Code	Subject Name	L	P	Credits
ME-MD1104.4	Non Destructive Evaluation **(Elective -I)**	3	0	3

Course Objectives

The objectives of the course are to

- ***Develop*** the conceptsof various NDE techniques using radiography, ultra Sonics, liquid penetrates, magnetic particles, eddy currents, infrared and thermal testing are deal with
- ***learn*** basic principles of these methods and select a testing process.
- ***understand*** the advantages and disadvantages of these techniques
- ***classify*** various nondestructive testing instruments.
- ***Explain*** the types of Non-destructive testing methods

Course Outcomes

1. ***Elucidate*** nondestructive testing techniques (L2)
2. ***understand*** the Ultrasonic Transducers and their Characteristics(L2)
3. ***illustrate*** Liquid Penetrate System and Eddy Current Test System.(L2)
4. ***understand*** the Principle of Magnetic Particle Testing.(L2)
5. ***explain*** the infrared and thermal testing procedure (L2)

Unit-I

Introduction to Non-Destructive Testing

Radiographic test**,** Sources of X and Gamma Rays and their interaction with Matter, Radiographic equipment, Radiographic Techniques, Safety Aspects of Industrial Radiography

Learning outcomes

At the end of this unit, the student will be able to

- ***elucidate*** nondestructive testing techniques.(L2)
- ***summarize*** the basic concepts of Radiographic test.(L2)
- ***outline*** the concepts of sources of X and Gamma Rays.(L2)
- ***explain*** the radiographic techniques.(L2)

Applications

Inspection of products:

Inspection of weldson pressurized piping, pressure vessels, high-capacity storage containers, pipelines and some structural welds.

1. Airport security: Both hold luggage and carry-on hand luggage are normally examined by X-ray machines using X-ray radiography.
2. Non-intrusive cargo scanning: Gamma radiography and high-energy X-ray radiography are currently used to scan intermodal freight cargo containers in US and other countries.

Unit-II

Ultrasonic Test

Principle of Wave Propagation, Reflection, Refraction, Diffraction, Mode Conversion and Attenuation, Sound Field, Piezo-electric Effect, Ultrasonic Transducers and their

Characteristics, Ultrasonic Equipment and Variables Affecting Ultrasonic Test, Ultrasonic Testing, Interpretations and Guidelines for Acceptance, Rejection-Effectiveness and Limitations of Ultrasonic Testing.

Learning outcomes
At the end of this unit, the student will be able to

- ***explain*** the principle of ultrasonic test.(L2)
- ***discuss*** the characteristics of ultrasonic transducers.(L2)
- ***outline*** the limitations of ultrasonic testing.(L2)

Applications:

1. Forging Test
2. Tube Testing

Unit-III

Liquid Penetrant Test
Liquid Penetrant Test, Basic Concepts, Liquid Penetrant System, Test Procedure, Effectiveness and Limitations of Liquid Penetrant Testing

Eddy Current Test
Principle of Eddy Current, Eddy Current Test System, Applications of Eddy Current Testing Effectiveness of Eddy Current Testing.

Learning outcomes
At the end of this unit, the student will be able to

- ***elucidate*** the procedure of Liquid Penetrant, eddy current tests.(L2)
- ***outline*** the limitations of Penetrant, eddy current tests.(L2)
- ***explain*** the effectiveness of Penetrant, eddy current tests.(L2)

Applications

1. Liquid penetrant inspection can be used successfully on nonporous and fairly smooth materials such as metals, glass, plastics and fired ceramics.
2. The two major applications of eddy current testing are surface inspection and tubing inspections.

Unit-IV

Magnetic Particle Test
Magnetic Materials, Magnetization of Materials , Demagnetization of Materials, Principle of Magnetic Particle Test, Magnetic Particle Test Equipment, Magnetic Particle Test Procedure, Standardization and Calibration, Interpretation and Evaluation, Effective Applications and Limitations of the Magnetic Particle Test.

Learning outcomes
At the end of this unit, the student will be able to

- ***illustrate*** the procedure of magnetic particle tests.(L2)
- ***outline*** the limitations of magnetic particle tests.(L2)
- ***explain*** the effectiveness of magnetic particle tests.(L2)

Applications

1. Surface defects

2. Welded joints
3. Components of pressure systems: boilers, pressure vessels, locomotives and tanks.

Unit-V

INFRARED AND THERMAL TESTING

Introduction and fundamentals to infrared and thermal testing–Heat transfer –Active and passive techniques –Lock in and pulse thermography _Contact and non contact thermal inspection methods–Heat sensitive paints –Heat sensitive papers –-thermally quenched phosphors liquid crystals –techniques for applying liquid crystals –other temperature sensitive coatings–Inspection methods–Infrared radiation and infrared detectors–thermo mechanical behavior of materials–IR imaging in aerospace applications, electronic components, Honey comb and sandwich structures–Case studies.

Learning outcomes:

At the end of this unit, the student will be able to

- ***understand*** the fundamentals of thermal testing.(L2)
- ***explain*** the techniques of liquid crystals, active and passive.(L2)
- ***illustrate*** thermal inspection methods.(L2)
- ***outline*** the limitations of thermal testing.(L2)

Applications:

1. Electrical and Mechanical System Inspection.
2. Electronic Component Inspection.
3. Corrosion Damage.
4. Flaw Detection.

Text Books

1. J Prasad, GCK Nair, Nondestructive test and evaluation of Materials, Tata mcgraw-Hill Education Publishers.
2. Josef Krautkrämer, Herbert Krautkrämer, Ultrasonic testing of materials, 3/e, Springer-Verlag.
3. X.P.V.Maldague, Nondestructive evaluation of materials by infrared thermography,1/e,Springer-Verlag.

References

1. Gary L.Workman, Patrick O.Moore, Doron Kishoni, Non-destructive, Hand Book, Ultrasonic Testing,3/e, Amer Society for Nondestructive.
2. ASTM Standards,Vol3.01,Metalsandalloys

Subject Code	Subject Name	L	P	Credits
ME-MD1105.1	Fracture Mechanics **(Elective - II)**	3	0	3

Course Objectives:

The objectives of the course are to

- learn the fracture behavior of different materials
- Understand the concept of fracture energy
- Acquire the knowledge of critical stress intensity factor
- understand the failure prediction parameters
- explain the Micro mechanisms of fatigue damage
- Compare of creep performance under different conditions

Course Outcomes

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

1. ***understand*** the failure mode of brittle and ductile materials(L2)
2. ***Explain*** the resistance to fracture versus crack extension(L2)
3. ***analyze*** the effect of thickness on fracture toughness(L4)
4. ***understand*** the crack tip opening displacement (CTOD)test that measures the resistance of a material to the propagation of a crack(L2)
5. ***analyze*** the factors enhancing the fatigue resistance(L4)

Unit-I

Introduction

Prediction of mechanical failure. Macroscopic failure modes; brittle and ductile behaviour. Fracture in brittle and ductile materials – characteristics of fracture surfaces; inter-granular and intra-granular failure, cleavage and micro-ductility, growth of fatigue cracks, The ductile/brittle fracture transition temperature for notched and un notched components. Fracture at elevated temperature.

Learning outcomes

After completion of this unit, students will be able to

- ***understand*** the failure mode of brittle and ductile materials(L2)

Unit-II

Griffiths analysis

Concept of energy release rate, G, and fracture energy, R. Modification for ductile materials, loading conditions. Concept of R curves.

Linear Elastic Fracture Mechanics, (LEFM). Three loading modes and the state of stress ahead of the crack tip, stress concentration factor, stress intensity factor and the material parameter the critical stress intensity factor, crack tip plasticity, effect of thickness on fracture toughness.

Learning outcomes

After completion of this unit, students will be able to

- ***explain*** the relationship between applied nominal stress and crack length at

fracture(L2)

- ***understand*** the concept of fracture energy(L2)

Unit-III

Elastic-Plastic Fracture Mechanics;(EPFM).

The definition of alternative
Failure prediction parameters, Crack Tip Opening Displacement, and the J integral.
Measurement of parameters and examples of use.

Learning outcomes

After completion of this unit, students will be able to

- ***explain*** the failure prediction parameters(L2)
- ***understand*** the crack tip opening displacement (CTOD)test that measures the resistance of a material to the propagation of a crack(L2)

Unit-IV

Fatigue: definition of terms used to describe fatigue cycles, High Cycle Fatigue, Low Cycle Fatigue, mean stress R ratio, strain and load control. S-N curves. Goodmans rule and Miners rule. Micro mechanisms of fatigue damage, fatigue limits and initiation and propagation control,

Leading to a consideration of factors enhancing fatigue resistance. Total life and damage to lerant approaches to life prediction.

Learning outcomes

After completion of this unit, students will be able to

- ***understand*** the fatigue cycle sand can plot SN curves(L2)

Unit-V

Creep deformation

The evolution of creep damage, primary, secondary and tertiary creep. Micro-mechanisms of creep in materials and the role of diffusion. Ashby creep deformation maps. Stress dependence of creep – power law dependence. Comparison of creep performance under different conditions–extrapolation and the use of Larson-Miller parameters. Creep-fatigue interactions. Examples.

Learning outcomes

After completion of this unit, students will be able to

- ***understand*** the mechanisms of creep in materials and the role of diffusion(L2)
- ***compare*** of creep performance under different conditions(L2)
- ***analyze*** the creep fatigue interactions(L4)
-

Text Books

1. T.L.Anderson, Fracture Mechanics Fundamentals and Applications,2nd Ed.CRC press
2. B.Lawn, Fracture of Brittle Solids, Cambridge Solid State Science Series2nded.
3. J.F.Knott, Fundamentals of Fracture Mechanics, Butter worths
4. J.F.Knott, PWithey, Worked examples in Fracture Mechanics, Institute of Materials.
5. H.L.Ewaldand R.J.H.Wanhill Fracture Mechanics, Edward Arnold

6. S.Suresh, Fatigue of Materials, Cambridge University Press
7. L.B.Freund and S.Suresh, ThinFilm Materials Cambridge University Press
8. G.E.Dieter, Mechanical Metallurgy, McGrawHill
9. D.C.Stoufferand L.T.Dame, Inelastic Deformation of Metals,Wiley
10. F.R.N.Nabarro, H.L.deVilliers, ThePhysics of Creep,Taylor and Francis

Subject Code	Subject Name	L	P	Credits
ME-MD1105.2	Design for Manufacturing and Assembly **(Elective- II)**	3	0	3

Course Objectives:

The objectives of the course are to

- Explain the product development cycle and manufacturing issues to be considered in design.
- Familiarize manufacturing consideration in cast, machining, cleaning and weld components.
- Describe the manufacture of machine components.
- Impart knowledge of manufacturing assembly of machine components.

Course Outcomes

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

1. ***design*** mechanical components with economical consideration.(L3)
2. ***select*** dimensional tolerance sand surface roughness values.(L3)
3. ***identify*** tolerances for various casting processes.(L3)
4. ***apply*** the design rules for design of dies.(L3)
5. ***understand*** contemporary issues and their impact on design for manufacturing and assembly.(L2)

Unit–I

Introduction to DFM, DFMA:

Need for DFM, Integrating DFMA with product design, Typical DFMA case studies, overall impact of DFMA in industrial products.

Design for Manual Assembly: General Design Guidelines for Manual Assembly, Development of the Systematic DFA Methodology, Assembly Efficiency, Effect of Part Symmetry, Thickness, Weight on Handling Time, Effects of Combinations of Factors, Application of the DFA Methodology.

Learning outcomes

At the end of the unit, student will be able to

- ***understand*** steps in design process.(L2)
- ***apply*** economical considerations at design stage.(L3)
- ***develop*** creativity attitude in designing.(L3)

Unit-II

Machining processes

Overview of various machining processes-general design rules for machining-dimensional tolerance and surface roughness-Design for machining–ease–redesigning of components for machining ease with suitable examples. General design recommendations for machined parts.

Learning outcomes

At the end of the unit, student will be able to

- ***illustrate*** various machining processes.(L2)
- ***Understand*** the dimensional tolerances and surface roughness values.(L2)
- ***identify*** the necessity of redesigning of the components.(L3)

Unit-III

Metal casting:
Appraisal of various casting processes, selection of casting process,-general design considerations for casting-casting tolerance-use of solidification, simulation in casting design-product design rules for sand casting.
Extrusion &Sheet metalwork: Design guidelines extruded sections-design principles for punching, blanking, bending, deep drawing-Keeler Goodman forging line diagram – component design for blanking.

Learning outcomes:
At the end of the unit, student will be able to

- ***understand*** Simulates and casting design.(L2)
- ***apply*** the design guidelines the extruded sections.(L3)
- ***apply*** the design principles for various sheet metal operations.(L3)

Unit-IV

Metal joining:
Appraisal of various welding processes, factors in design of weldments – general design guidelines-pre and post treatment of welds-effects of thermal stresses in weld joints- design of brazed joints. Forging: Design factors for forging – closed die forging design – parting lines of dies–drop forging die design–general design recommendations.

Learning outcomes*:*
At the end of the unit, student will be able to

1. ***understand*** the general guidelines.(L2)
2. ***apply*** the design rules for design of dies.(L3)

Unit–V

Design for Assembly Automation:
Fundamentals of automated assembly systems, System configurations, parts delivery system at workstations, various escapement and placement devices used in automated assembly systems, Quantitative analysis of Assembly systems, Multi station assembly systems, single station assembly lines.

Learning outcomes:
At the end of the unit, student will be able to

1. ***explain*** the Fundamentals of automated assembly systems.(L2)
2. ***explain*** Quantitative analysis of Assembly systems.(L2)

Text Books

1. Design for manufacture, John cobert, AdissonWesley
2. Design for Manufacture by Boothroyd,
3. Design for manufacture, James Bralla

Reference

1. ASMHandbookVol.20

Subject Code	Subject Name	L	P	Credits
ME-MD1105.3	Robotics **(Elective - II)**	3	0	3

Course Objectives:

The objectives of the course are to

- explain the fundamentals of robots.
- familiarize the robots as a mechanisms, matrix representation-representation of a point in a space.
- Describe the Forward and inverse kinematics of robots and its equations for position.
- Acquire knowledge on the robotic systems
- develop student's skills in perform kinematics analysis of robot systems
- Troubleshoot and recover from common robot program errors and faults
- path planning for a robotic system.
- calculate the forward kinematics and inverse kinematics of serial and parallel robots.

Course Outcomes

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

1. ***explain*** the fundamentals of robots.(L2)
2. ***analyze*** the mechanism of transformations in robots(L4)
3. ***explain*** the differential motions of a robot (L2)
4. ***analyze*** the Lagrangian mechanics, Effective moments of inertia, dynamic equations for multi-degree of freedom robots.(L4)
5. ***Analyze*** the characteristics of Actuating systems.(L4)

UNIT–I

Fundamentals of Robots

Introduction, definition of robot, classification of robots, History of robotics, robot components, degree of freedom, robot joints, robot coordinates, reference frames, programming modes, robot characteristics, robot workspace, robot languages, advantages, disadvantages and applications of robots.

Learning outcomes:

At the end of the unit, student will be able to

1. ***explain*** the Fundamentals of robots.(L2)

UNIT–II

Matrix transformations

Introduction, robots as a mechanisms, matrix representation-representation of a point in a space, representation of a vector in space, representation of a frame at the origin of a reference frame, representation of a frame in a reference frame, representation of a rigid body.

Homogeneous transformation matrices, representation of a pure translation, pure rotation about an axis, representation of combined transformations, transformations relative to the rotating, inverse of transformation matrices.

Robot kinematics

Forward and inverse kinematics of robots-forward and inverse kinematic equations for position, forward and inverse kinematic equations for orientation, forward and inverse kinematic equations for position and orientation, Denavit-Hartenberg (D-H) representation of forward kinematic equations of robots, The inverse kinematic solution and programming of robots, Degeneracy and Dexterity, simple problems with D-H representation.

Learning outcomes:

At the end of the unit, student will be able to

1. ***analyze*** the translation, rotation combined transformations in robots(L4)
2. ***explain*** the kinematic motion in robots.(L2)

UNIT–III

Differential motions and Velocities

Introduction, differential relationship, Jacobian, differential motions of a frame-translations, rotation, rotating about a general axis, differential transformations of a frame. Differential changes between frames, differential motions of a robot and its hand frame, calculation of Jacobian, relation between Jacobian and the differential operator, Inverse Jacobian.

Learning outcomes:

At the end of the unit, student will be able to

1. ***explain*** the differential motions of a frame-translations, rotation, rotating about a general axis of robots.(L2)

UNIT–IV

Dynamic analysis and forces:

Introduction, Lagrangian mechanics, Effective moments of inertia, dynamic equations for multi-degree of freedom robots-kinetic energy, potential energy, the Lagrangian, robot's equations of motion, static force analysis of robots.

Trajectory planning:

Introduction, path Vs trajectory, basics of trajectory planning, joint space trajectory planning-third order polynomial trajectory planning, fifth order polynomial trajectory planning, Cartesian-space trajectories.

Learning outcomes:

At the end of the unit, student will be able to

1. ***analyze*** the dynamic motion in robots.(L4)

UNIT–V

Robot Actuators:

Introduction, characteristics of Actuating systems-weight, power to weight ratio, operating pressure, stiffness Vs compliance, comparison of actuating systems, hydraulic devices, pneumatic devices, Electric motors-DC motorcar motors, Brushless DC motors, direct Drive

electric motors, servomotors, stepped motors.

Robot sensors:

Introduction, sensor characteristics, Position sensors potentiometers, encoders, LVDT, Resolvers, time of travel displacement sensor, Velocity sensors-Encoders, Tachometers, differentiation of position signal, Accelerating sensors, force and pressure sensors-piezoelectric, force sensing resistor, strain gauges, Torque sensors, light and infrared sensors, touch and tactile sensors, proximity sensors-magnetic proximity sensors, optical proximity sensors, Ultrasonic proximity sensors, inductive proximity sensors, capacitive proximity sensors, eddy current proximity sensors, sniff sensors.

Learning outcomes:

At the end of the unit, student will be able to

1. ***analyze*** the characteristics of Actuating systems.(L4)
2. ***explain*** the concept of robot sensors (L2)

TEXTBOOKS:

1. Introduction to Robotics–Analysis, System, Applications by Saeed B.Niku, PHI Publications
2. Industrial Robotics–Mikell P.Groover & Mitchell Weiss, Roger N.Nagel, Nicholas G.Odrey– McGrawHill,

REFERENCES:

1. Robot Modeling and Kinematics – Rachid Manseur, Firewall Media Publishers (An imprint of Laxmi Publications Pvt.Ltd., NewDelhi)
2. Robot Analysis and Control - H.Asada and J.J.E.Slotine John Willey & Sons.
3. Fundamentals of Robotics: Analysis and control, RobertJ.Schilling , PrenticeHall.
4. A robot Engineering textbook– Mohsenshahinpoor, Harper &RowPublishers,
5. Introduction to Robotics: Mechanics and Control,John.J.Craig,Addison-Wesley,
6. Robotics: Control, sensing, vision, and intelligence–K.S.FU, R.C.Gonzalezand C.S.G Lee.McGrawHill
7. Modeling and control of Robot manipulators, L. sciavicco and b. Siciliano, Springer.
8. ROBOTICS (Fundamental concepts and analysis) ASHITAVA GHOSAL. Oxford university press.

Subject Code	Subject Name	L	P	Credits
ME-MD1105.4	Advanced Machine Design **(Elective - II)**	3	0	3

Course Objectives:

The objectives of the course are to

- To explain the product design philosophy.
- To familiarize the Failure theories.
- Describe the fatigue damage, thermal fatigue of materials.

Course Outcomes

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

1. ***explain*** the **v**arious design models.(L3)
2. ***identify*** the different types of failures theories.(L3)
3. ***explain*** the fatigue damage, thermal fatigue of materials
4. ***understand*** the concept of surface failure.(L2)
5. ***analyze*** the economic factors influencing design.(L4)

UNIT-I

Design philosophy

Design process, Problem formation, Introduction to product design, Various design models-Shigley model, Asimov model and Norton model, Need analysis, Strength considerations - standardization. Creativity and Creative techniques, Material selection in machine design, design for safety and Reliability, concept of product design

Learning outcomes:

At the end of the unit, student will be able to

- ***develop*** the ability of Planning and Preparation in design philosophy.(L3)

UNIT-II

Failure theories

Static failure theories, Distortion energy theory, Maximum shear stress theory, Coulomb-Mohr's theory, Modified Mohr's theory, Fracture mechanics theory, Fatigue mechanisms, Fatigue failure models, Design for fatigue strength and life, creep: Types of stress variation, design for fluctuating stresses, design for limited cycles, multiple stress cycles

Learning outcomes:

At the end of the unit, student will be able to

- ***explain*** the different types of failures theories. (L3)

UNIT-III

Fatigue failure theories: Cumulative fatigue damage, thermal fatigue and shock, harmful and beneficial residual stresses, Yielding and transformation.

Learning outcomes:

At the end of the unit, student will be able to

- ***explain*** the concept of fatigue failures theories. (L3)

UNIT-IV

Surface failures

Surface geometry, mating surfaces, oil film and their effects, design values and procedures,

adhesive wear, abrasive wear, corrosion wear, surface fatigue, different contacts, dynamic contact stresses, surface fatigue failures, surface fatigue strength.

Learning outcomes:

At the end of the unit, student will be able to

- ***explain*** the concept of surface failures theories. (L3)

UNIT-V

Economic factors influencing design: Economic analysis, Break-even analysis, Human engineering considerations, Ergonomics, Design of controls, Design of displays. Value engineering, Material and process selection in value engineering, Modern approaches in design. Team work and Ethics in engineering design: Team formation, functioning, discharge, team dynamics, Ethical issues considered during engineering design process

Learning outcomes:

At the end of the unit, student will be able to

- ***explain*** the economic analysis of material selection process. (L3)

TEXTBOOKS:

1. Machine Design An Integrated Approach by Robert L.Norton, Prentice-Hall New Jersey, USA.
2. MechanicalEngineeringDesignbyJ.E.ShigleyandL.D.MitchellpublishedbyMcGrawHillInternationalBookCompany,NewDelhi.

REFERENCES:

1. Fundamentals of machine elements by Hamrock, Schmid and Jacobian, 2nd edition, McGraw-Hill International edition.
2. Product design and development by KarlT.Ulrichand Steven D.Eppinger.3rd edition, TataMcGraw Hill.
3. Product Design and Manufacturing by A.K. Chitaleand R.C. Gupta, Prentice Hall
4. Engineering Design/George E Dieter/ Mc Graw Hill.
5. Fundamentals of machine elements/Hamrock, Schmid and Jacobian/2nd edition/McGrawHill International edition

Subject Code	Subject Name	L	P	Credits
ME-MD1106	Machine Dynamics Laboratory	0	4	2

Course Objectives:

The objectives of the lab are

- To determine the frequency of damped and undamped free and forced vibrations.
- To determine static and dynamic balancing using rigid blocks.
- To analyze the motion of a gyroscope.
- To find whirling speed of shaft
- To find the natural frequencies using FFT Analyzer.
- To study the tribological performance of materials using pin-on-disc.
- To find the position of sleeve under controlling force.
- To observe the effect of damping in Forced Vibration of SDOF system due to base excitation.
- To Study the response of the vibration absorber for different excitation frequency and amplitude.

Course Outcomes:

On completion of this lab student will be able to

1. ***measure*** the frequency of damped and undamped at free and forced vibration of an equivalent spring mass system. (L5)
2. ***evaluate*** critical speed of shaft, by varying different speeds, balancing of masses, effect of Gyroscopic couple (L4)
3. ***determine*** the natural frequency of given structure using FFT analyzer, Study the tribological characteristics using pin-on-disc equipment (L5)
4. ***determine*** the sleeve positions of Hartnell governor for different speeds (L5)
5. ***analyze*** the response of the vibration absorber for different excitation frequency and amplitude(L4)

EXPERIMENTS:

1. Determination of damped natural frequency of the vibrating system with different viscous oils
2. Determination of steady state amplitude of a forced vibratory system
3. Static balancing using steel balls & Determination of the magnitude and orientation of the balancing mass in dynamic balancing
4. Determination of the magnitude of gyroscopic couple, angular velocity of precession, and representation of vectors.
5. Determination of natural frequency of given structure using FFT analyzer
6. Diagnosis of a machine using FFT analyzer.
7. An experiment on friction, wear, pin-on-disc
8. To determine the whirling speed of the shaft theoretically and experimentally.
9. To determine the position of sleeve against controlling force and speed of a Hartnell governor and to plot the characteristic curve of radius of rotation.
10. To find the moment of inertia of a flywheel
11. To observe the effect of damping in Forced Vibration of Single Degree of Freedom due to Base Excitation
12. To understand the dynamic vibration absorber system as simplified single degree of freedom system and study its characteristics for different excitation frequency and amplitude and masses.

Subject Code	Subject Name	L	P	Credits
ME-MD1107	Advanced Computer aided modelling laboratory	0	4	2

Course Objectives:

The objectives of the lab are to

- Utilize CATIA and Pro-E and software for modeling, tolerance & GD&T analysis of a product.
- Make use of CATIA software to model a consumer product and industrial robot.

Course Outcomes:

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

1. ***design*** 3D Models of parts with CATIA Software. (L6)
2. ***develop*** consumer products and Industrial robots(L6)
3. ***apply*** Boolean based Modelling features for Surface Modelling (L3)
4. ***make use of*** Computer Aided Modelling software for Modelling, Tolerance and GD& T Analysis of a product.(L3)
5. ***model*** Assembly Modelling of the required products using any CAD Software(L3)

DRAFTING:

1. Development of part drawings for various components in the form of orthographic and isometric.

PART MODELING:

1. Generation of various 3D Models through pad, shaft, shell sweep.

2. Feature based and Boolean based modeling surface and Assembly Modeling. Design simple components.

3. Setting up of drawing environment by setting drawing limits, drawing units, naming the drawing, naming layers, setting line types for different layers using various type of lines in engineering drawing, saving the file with .dwg extension.

4. To make an isometric dimensional drawing of a connecting rod.

5. Draw Different type's bolts and nuts with internal and external threading in Acme and Square threading standards. Save the bolts and nut as blocks suitable for insertion.

6. To model and assemble the flange coupling as per the dimensions given and also convert the 3D model into different views

7. To model and assemble the Screw jack as per the dimensions given and also convert the 3D model into different views.

8. To model and assemble the strap joint of Gib & cotter as per the dimensions given and also convert the 3D model in to different view.

9. Various Dimensioning and tolerancing techniques on typical products using CAD software.

10. Simulation of Kinematic Mechanism using MS Adams Package

.I Year- II Semester

Code	Subject Name	L	T	P	C
ME-MD1201	Experimental Stress Analysis	3	0	0	3

Course Objectives:

The objectives of the course are to

- Familiarize with three-dimensional stress strain relations.
- Explain photo elastic materials.
- Discuss the static recording and data logging.
- Explain the brittle coating and crack patterns.

Course Outcomes:

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

- ***Develop*** the ability to obtain the plane stress and plane strain conditions(L3)
- ***select*** the strain Measurement and Recordings(L2)
- ***analyze*** the principles of Photo elasticity(L4)
- ***solving*** for geometrical approach to Moire- Fringe analysis.(L3)
- ***design*** for Fringe-order determinations in coatings.(L3)

Unit–I

Introduction: Stress, strain, Plane stress and plane strain conditions, Compatibility conditions. Problems using plane stress and plane strain conditions, stress functions, mohrs circle for stress strain, Three-dimensional stress strain relations.

Learning outcomes:

At the end of the unit, student will be able to

- ***develop*** the ability to obtain the plane stress and plane strain conditions (L3)
- ***develop*** mohrs circle for stress strain.(L3)

Unit–II

Strain Measurement and Recordings: Various types of strain gauges, Electrical Resistance strain gauges, semi conductor strain gauges, strain gauge circuits. Introduction, static recording and data logging, dynamic recording at very low frequencies, dynamic recording at intermediate frequencies, dynamic recording at high frequencies, dynamic recording at very high frequencies ,telemetry systems.

Learning outcomes:

At the end of the unit, student will be able to

- ***select*** the strain Measurement and Recordings(L2)
- ***design*** for dynamic recording at high frequencies.(L3)

Unit–III

Photo elasticity: Photo elasticity – Polari scope – Plane and circularly polarized light, Bright and dark field setups, Photo elastic materials–Isochromatic fringes–Isoclinics

Three dimensional Photo elasticity : Introduction, locking in model deformation, materials for three-dimensional photo elasticity, machining cementing and slicing three-dimensional models, slicing the model and interpretation of the resulting fringe patterns, effective stresses, the shear-difference method in three dimensions, applications of the Frozen-stress method, the scattered-light method.

Learning outcomes:

At the end of the unit, student will be able to

- ***analyze*** the Principles of Photo elasticity(L4)
- ***design*** for Isochromatic fringes.(L3)

Unit–IV

Brittle coatings: Introduction, coating stresses, failure theories, brittle coating crack patterns, crack detection, ceramic based brittle coatings, resin based brittle coatings, test procedures for brittle coatings analysis, calibration procedures, analysis of brittle coating data.

Moire Methods: Introduction, mechanism of formation of Moire fringes, the geometrical approach to Moire-Fringe analysis, the displacement field approach to Moire-Fringe analysis, out of plane displacement measurements, out of plane slope measurements, sharpening and multiplication of Moire-Fringes, experimental procedure and techniques.

Learning outcomes:

At the end of the unit, student will be able to

- ***solve*** geometrical approach to Moire- Fringe analysis.(L3)
- ***apply*** the geometrical approach to Moire-Fringe analysis(L3)

Unit–V

Birefringent Coatings

Introduction, Coating stresses and strains, coating sensitivity, coating materials, application of coatings, effects of coating thickness, Fringe-order determinations in coatings, stress separation methods.

Learning outcomes:

At the end of the unit, student twill be able to

- ***design*** for Fringe-order determinations in coatings.(L3)
- ***elucidate*** stresses parathion methods.(L2)

Text Books

1. Theory of Elasticity by Timoshenke and GoodierJr
2. Experimental stress analysis by Dally and Riley, McGraw-Hill

References

1. Atreatiseon Mathematical theory of Elasticity by LOVE.A.H
2. Photo Elasticity by Frocht
3. Experimental stress analysis, Video course by K.Ramesh / NPTEL

Code	Subject Name	L	T	P	C
ME-MD1202	Advanced Finite Element Method	3	0	0	3

Course Objectives:

The objectives of the course are to

- Familiarize basic concepts of formulation techniques procedure.
- Explain theory and characteristics of finite elements structural applications using truss.
- Explain the use of finite elements for to analyze beams.
- Applythefiniteelementsolutionstosolve2Dproblemsliketriangularandaxi–symmetricalsolids.
- Explain the finite element solutions to solve heat transfer problems.
- Explain the use of finite solutions to solve the problems involving dynamics.

Course Outcomes:

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

1. ***Understand*** the concepts behind variational methods and weighted residual methods in FEM.(L2)
2. ***explain*** the characteristics of FEA elements for trusses and beams.(L2)
3. ***explain*** the formulation of two–dimensional elements(L2)
4. ***elucidate*** the parametric representation.(L2)
5. ***apply*** the finite element method for problems involving dynamics.(L3)

Unit-I

Formulation Techniques: Methodology, Engineering problem and governing differential equations, finite elements, Variational methods-potential energy method, Raleigh Ritz method, strong and weak forms, Galerkin and weighted residual methods, calculus of variations, Essential and natural boundary conditions.

Application: analysis of structures

Learning Outcomes:

At the end of the unit, the student will be able to

- ***explain*** the numerical methods involved in Finite Element theory.(L2)
- ***understand*** the role and significance of shape functions.(L2)
- ***solve*** axially loaded bar problems.(L3)

Unit–II

One-dimensional elements: Bar, trusses, beams and frames, displacements, stresses and temperature effects.

Application: analysis of structures

Learning Outcomes:

At the end of the unit, the student will be able to

- ***understand*** the numerical methods involved in Finite Element theory.(L2)
- ***solve*** axially loaded bar problems.(L3)

Unit–III

Two dimensional problems: CST, LST, four noded and eight nodded rectangular elements, Lagrange basis for triangles and rectangles, serendipity interpolation functions. Axisymmetric Problems: Axisymmetric formulations, Element matrices, boundary conditions. Heat Transfer problems: Conduction and convection, examples:-two-dimensional fin.

Application: hollow cylindrical elements, Analysis of plates

Learning Outcomes:

At the end of the unit, the student will be able to

- ***explain*** the formulation of two–dimensional elements(L2)
- ***apply*** the formulation techniques to solve two–dimensional problems using triangle

and quadrilateral elements.(L3)

- ***solve*** axisymmetric problems.(L3)

Unit–IV

Iso parametric formulation: Concepts, sub parametric, super parametric elements, numerical integration, Requirements for convergence, h-refinement and p-refinement, complete and incomplete interpolation functions, Pascal's triangle, Patch test.

Learning Outcomes:

At the end of the unit, the student will be able to

- ***explain*** the parametric representation.(L2)
- ***understand*** complete and incomplete interpolation functions.(L2)

Unit–VI

Finite elements in Structural Analysis: Static and dynamic analysis, eigen value problems, and their solution methods, case studies using commercial finite element packages.

Application: Analysis of potential noise and vibration problems.

Learning Outcomes:

At the end of the unit, the student will be able to

- ***understan***d problems involving dynamics using Finite Element Methods.(L2)
- ***apply*** the Eigen values and Eigen Vectors for stepped bar.(L3)
- ***explain*** the process of meshing and application of boundary conditions.(L2)

Text Book

1. Finite element methods by Chandrubatla & Belagondu.
2. S.S.Rao, The Finite Element Methods in Engineering, Elsevier Butter worth-Heinemann2nd Edition.

References

1. J.N.Reddy, Finite element method in Heat transfer and fluid dynamics, CRC press
2. Zienckiwicz O.C.& R.L.Taylor, Finite Element Method, McGraw-Hill.
3. K.J.Bathe, Finite element procedures, Prentice-Hall

Subject Code	Subject Name	L	P	Credits
ME-MD1203	Mechanical Vibrations	3	0	3

Course Objective:

The objectives of the course are to

- Develop equation of motion for discrete spring-mass systems with different configuration using classical and energy methods.
- Apply the concepts of forced vibrations, vibration transmissibility and isolation and seismic instruments.
- Familiarize with two degree freedom system and various types of vibration absorbers.
- Analyze the two degree and multi degree of freedom systems.
- Explain the Vibration measuring devices and their applications.

Course outcomes:

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

1. ***calculate*** the natural frequency of un-damped single degree freedom systems(L3)
2. ***analyze*** the Response to Non Periodic Excitations (L4)
3. ***calculate*** natural frequencies of multi degree freedom system.(L3)
4. ***solve*** the Natural Frequencies Rayleigh and Dunkerleys method(L3)
5. ***determine*** the Critical speeds without and with damping.(L3)

Unit I

Single degree of Freedom systems: Un damped and damped free vibrations: forced vibrations ; coulomb damping; Response to harmonic excitation; rotating unbalance and support excitation, Vibration isolation and transmissibility, Vibrometers, velocity meters& accelerometers.

Applications: bridges, buildings, mechanical engineering and aerospace structures

Learning Outcomes:

After completion of this unit student will able to

1. ***understand*** the behavior of single degree freedom systems with damping.(L2)
2. ***illustrate*** working of Vibrometers, velocity meters &accelerometers. .(L2)

Unit II

Response to Non Periodic Excitations: unit Impulse, unit step and unit Ramp functions; response to arbitrary excitations, The Convolution Integral; shock spectrum; System response by the Laplace Transformation method.

Applications: Motor pump *s*ystem. There are two equationsofmotionfora2DOFsystem

Learning Outcomes:

After completion of this unit the students will be able to

1. ***understand*** unit Impulse, unit step and unit Ramp functions (L2)
2. ***apply*** Laplace Transformation method for System response. (L3)

Unit III

Multi degree freedom systems: Principal modes–undamped and damped free and forced vibrations ; undamped vibration absorbers, Matrix formulation, stiffness and flexibility influencecoefficients;Eigenvalueproblem;normalmodesandtheirproperties;Freeandforcedvibrationby Modal analysis; Method of matrix inversion; Torsional vibrations of multi – rotor systems and geared systems; Discrete-Time systems.

Applications: motor pump ***system***. There are ***two*** equations of motion for a 2 DOF ***system***

Learning Outcomes:

After completion of this unit the students will be able to

1. ***explain*** the undamped and damped free and forced vibrations (L2)
2. ***apply*** the Method of matrix inversion for Torsional vibrations of multi – rotor systems and geared systems .(L3)

Unit IV

Numerical Methods: Rayliegh's, stodola's, Matrix iteration, Rayleigh-Ritz Method and Holzer's methods

Learning Outcomes:

After completion of this unit the students will be able to

1. ***explain*** the steps in Numerical Methods (L2)
2. ***apply*** the numerical methods for vibration problems(L3)

Unit V

Application of concepts: Free vibration of strings – longitudinal oscillations of bars-transverse vibrations of beams- Torsional vibrations of shafts. Critical speeds without and with damping, secondary critical speed.

Applications: microphone's sensitivity, applied in an industrial or maintenance.

Learning Outcomes:

After completion of this unit the students will be able to

1. ***explain*** the working principle of vibration pickups(L2)
2. ***understand*** the torsional vibrations of shafts (L2)

Textbooks

1. Elements of Vibration Analysis by Meirovitch.
2. Mechanical Vibrations by G.K.Groover.

References

1. Vibrations by W.T.Thomson
2. Mechanical Vibrations–Schaumseries.
3. Vibration problems in Engineering by S.P.Timoshenko.
4. Mechanical Viabrations –V.RamMurthy.

Code	Subject Name	L	T	P	C
ME-MD1204.1	Material Selection in Mechanical Design (**Elective-III**)	3	0	0	3

Course Objectives:

The objectives of the course are to

- Competence with a set of tools and methods for product design and development.
- Confidence in your own abilities to create a new product.
- Awareness of the role of multiple functions in creating a new product (e.g. marketing, finance, industrial design, engineering, production).
- Ability to coordinate multiple, inter disciplinary tasks in order to achieve a common objective.
- Reinforcement of specific knowledge from other courses through practice and reflection in an action-oriented setting.
- Enhanced team working skills.

Course Outcomes:

After completion of this unit, students will be able to

1. ***elucidate*** the concepts and principles of advanced materials and manufacturing processes(L2)
2. ***illustrate*** different material property charts to understand and select best possible materials for typical applications.(L2)
3. ***understand*** various steels and different Super Alloys with their strengthening mechanism, composition properties.(L2)
4. ***explain*** about different composite materials and its processing methods.(L2)
5. ***outline*** different smart materials and with their application.(L2)

Unit–I

Fundamentals of material science: Elasticity in metals, mechanism of plastic deformation, sliptwinning,roleofdislocations,yieldstress,shearstrengthofperfectandrealcrystals,strengthening mechanism, work hardening, solid solution, grain boundary strengthening, Polyphase mixture, precipitation, particle, fiber and dispersion strengthening, effect of temperature, strain and strain rate on plastic behavior, super plasticity. Yield criteria: Von mises and Tresca criteria.

Application: Advanced materials like nanomaterials, smart materials

Learning Outcomes: After completion of this unit, students will be able to

1. ***outline*** different properties of materials(L2)
2. ***explain*** the Properties and test them(L2)

Unit–II

Motivation of selection, cost basis and service requirements, selection for mechanical properties, strength, toughness, fatigue, impact and creep, use of material property charts for material selection.

Application: Best possible materials selection for typical uses

Learning Outcomes: After completion of this unit, students will be able to

1. ***explain*** the material selection and a number of common property combinations(L2)
2. ***select*** suitable material based on experiments.(L3)

Unit–III

Modern metallic Materials: Dual phase steels, micro alloyed steels, high strength low alloy(HSLA) Steel, maraging steel, inter metallic, Ni and Ti aluminides, super alloys.

Application: Hip joints, Bone plates and screws

Learning Outcomes: After completion of this unit, students will be able to

1. ***illustrate*** different phases of steels(L2)
2. ***explain*** the Properties of super alloys(L2)

Unit–IV

Non metallic materials: Polymeric materials and their molecular structures, production techniques for fibers, foams, adhesives and coatings, structure, properties and applications of engineering polymers.

Composites: Introduction, reinforcement ,types of composite materials,- properties, processing and application of composite materials.

Application: Fiber reinforced composite, Thermo setting plastics, thermo Plastics, anti pollutant coatings

Learning Outcomes: After completion of this unit, students will be able to

1. ***understand*** polymeric structures and its applications(L2)
2. ***explain*** different foams, adhesives and its properties and applications(L2)

Unit–V

Properties, structure and applications of Smart materials, shape memory alloys, metallic glass, quasi crystal and nano crystalline materials, ceramic materials, ceremets, high temperature materials, refractory materials.

Application: Piezo electric material, Electro active polymer (EAP),Magnet ostrictive material

Learning Outcomes: After completion of this unit, students will be able to

1. ***illustrate*** the applications and its processing methodologies of smart materials(L2)
2. ***explain*** different crystalline materials(L2)

Text Books

1. Mechanical behavior of materials/Thomas H.Courtney/2nd Edition,McGraw-Hill
2. Mechanical Metallurgy /George E.Dieter/McGraw Hill
3. Material selction in mechanical design by M.FAshby. Bott
4. E.PaulDegarmo,J.T.Black, and Ronald A Kohser."Materials and Processing in Manufacturing," John Wiley and Sons Inc
5. K.K.Chawla, "Composite Materials: Science & Engineering," Springer-Verlag, NewYork,
6. A.K.Sinha."Powder Metallurgy," Dhanpat Rai Publications.

References

1. Selection and use of Engineering Materials 3e / Charles J.A/ Butterworth Heiremann. Material science and metallurgy by V.D. Kodgire, Everest publishing house.
2. Mich Wilson, Kamali kannangara, et.Al., "Nano Technology: Basic Science and Emerging Technology," Chapman and Hall / CRC
3. V.S.R Murthy, A.K.Jena, K.P.Gupta and G.S.Murthy, "Structure and Properties of Engineering Materials, "Tata McGraw Hill Education.

Code	Subject Name	L	T	P	C
ME-MD1204.2	Condition Monitoring and Signal Analysis **(Elective-III)**	3	0	0	3

Course objectives

The objectives of the course are to

- Explain basics of the theory and practice of Condition monitoring
- Awareness on experimental techniques in Condition monitoring
- Understand the primary signal processing techniques
- understand advanced methods in conditioning monitoring.
- Develop knowledge on Tool wear monitoring techniques.

Course outcomes

At the end of the Course, the student will be able to

1. ***illustrate*** techniques of data Collection for the analysis of vibration monitoring(L2)
2. ***apply*** experimental techniques in Condition monitoring(L3)
3. ***understand*** the primary signal processing techniques(L2)
4. ***explain*** the basics of the theory and practice of Condition monitoring(L2)
5. ***understand*** advanced methods for Condition monitoring (L2)

Unit I

Vibration monitoring, bearing and gear faults: Introduction, vibration data Collection, techniques, instruments, transducers, selection, measurement location, time domain analysis, frequency domain analysis, time-frequency domain analysis and commonly witnessed machinery

faults diagnosed by vibration analysis. Vibration signals from rotating and reciprocating machines –signal classification, signals generated by rotating machines, signals generated by reciprocating machines. Introduction, Construction, types of faults, rolling element, rolling element bearing diagnostics and gear diagnostics.

Application: Testing and analysis to ensure products Comply with specified vibration tolerance limits

Learning outcomes:

After Completion of this unit, students will be able to

- ***identify*** the Commonly witnessed machinery faults diagnosed by vibration analysis.(L3)
- ***illustrate*** vibration signals from rotating and reciprocating machines and classify signals (L2)

Unit II

Basic signal processing techniques: Probability distribution and density, Fourier analysis, Hilbert transform cestrum analysis, digital filtering, deterministic/random signal separation, time-frequency analysis

Learning outcomes:

After Completion of this unit, students will be able to

- ***explain*** the essential elements of an automated system related to different manufacturing industries(L2)
- ***elucidate*** Basic signal processing techniques(L2)

Unit III

Wavelet transform: Introduction to wavelets, Continuous wavelet transform (cwt), discrete wavelet transform (DWT), wavelet packet transform (WPT), types of wavelets – haarwavelets, shann on wavelets, meyer wavelets, daubechies wavelets, CO if man wavelets and applications of wavelets.

Application: pattern recognition, edge recognition

Learning outcomes:

After Completion of this unit, students will be able to

- ***explain*** various wavelet transforms such as Continuous, discrete, wavelet packet transforms(L2)
- ***identify*** various types of wavelets(L3)
- ***classify*** wavelets such as haar wavelets, shannon wavelets, meyer wavelets, daubechies wavelets, Coffman wavelets and applications of wavelets.(L2)

Unit IV

Introduction to Condition monitoring: Basic Concept, techniques-visual monitoring, temperature monitoring, vibration monitoring, lubricant monitoring, crack monitoring, thickness monitoring, noise and sound monitoring.

Application: monitoring of temperature, crack, thickness in assembly plant

Learning outcomes:

After Completion of this unit, students will be able to

- ***list*** the techniques for Condition monitoring(L1)
- ***explain*** various Condition monitoring techniques (L2)

Unit V

Other methods in Condition monitoring: Wear monitoring and lubricant analysis - sources of Contamination, techniques, spectrometric oil analysis procedure (soap)and ferrography, radiographic test**,** sources of x and gamma rays and their interaction with matter, radiographic equipment, radiographic techniques, safety aspects of industrial radiography. Machine tools wear monitoring techniques and case studies.

Learning outcomes:

After Completion of this unit, students will be able to

- ***illustrate*** spectro metric oil analysis and ferrography and radiographic tests(L2)
- ***explain*** different tool wear techniques(L2)

Test Book

1.Condition Monitoring of Mechanical Systems/Kolacat.

References

1. Frequency Analysis/R.B.Randall.
2. Mechanical Vibrations Practice with Basic Theory/ V.Ramamurti/ Narosa Publishing House.
3. Theory of Machines and Mechanisms/Amitabh Ghosh& AKMalik/EWP

Code	Subject Name	L	T	P	C
ME-MD1204.3	Vehicle Dynamics **(Elective-III)**	3	0	0	3

Course Objectives:

The objectives of the course are to

- Understand the dynamics of vehicle ride
- Calculate and refer the loads and forces associated to the vehicles
- Analyze the behavior of the vehicles under acceleration, ride and braking

Course Outcomes:

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

1. ***evaluate*** the performance characteristics of Vehicle(L4)
2. ***analyze*** the mechanics of airflow around a vehicle.(L4)
3. ***design*** the tire of an automobile by considering breaking, cornering etc. (L3)
4. ***analyze*** the suspension system of an automobile.(L4)
5. ***analyze*** the forces and moments during design of a steering mechanism(L4)

Unit-I

Performance Characteristics of Vehicle: SAE Vehicle axis system, Forces & moments affecting vehicle, Earth Fixed coordinate system, Dynamic axle loads, Equations of motion, transmission characteristics, vehicle performance, power limited and traction limited acceleration, braking performance, Brake proportioning, braking efficiency.

Learning outcomes:

After Completion of this unit, students will be able to

- ***explain*** the Forces & moments affecting vehicle (L2)
- ***understand*** braking efficiency(L2)

Unit-II

Aerodynamics: Mechanics of Air Flow A round a Vehicle, Pressure Distribution on a Vehicle, Aero dynamic Forces, Drag Components, Aero dynamics Aids.

Learning outcomes:

After Completion of this unit, students will be able to

- ***analyze*** the mechanics of airflow around a vehicle.(L4)

Unit-III

Tire Mechanics: Tire Construction, Size and Load Rating, Terminology and Axis System, TractiveProperties,CorneringProperties,CamberThrust,AligningMoment,CombinedBraking andCornering,ConicityandPlySteer,Slip,Skid,RollingResistance,ElasticBandModelforlongitudinal slip, Simple model for lateral slip, Combined longitudinal/lateral slip (friction ellipse),Tautstring model for lateral slip, Magic Tire Formula

Learning outcomes:

After Completion of this unit, students will be able to

- ***design*** the tire of an automobile by considering breaking, cornering etc. (L3)

Unit-IV

Suspensions: Suspension Kinematics, Suspension types, Solid Axles, Independent Suspensions, Anti-Squat and Anti-Pitch Suspension Geometry, Anti-Dive Suspension Geometry, Roll Center Analysis, Suspension Dynamics,Multi-bodyvibration,BodyandWheelhopmodes,Invariantpoints, Controllable Suspension Elements: Active, Semi-Active. Choice of suspension spring rate, Calculation of effective spring rate, Vehicle suspension in fore and apt directions

Learning outcomes:

After Completion of this unit, students will be able to

- ***illustrate*** the types of suspension systems of an automobile.(L2)
- ***explain*** Controllable Suspension Elements.(L2)

Unit-V

The Steering System: The Steering Linkages, Steering System Forces and Moments, Steering System Models, Steering Geometry, Steady Handling (2 DOF steady-state model), Under steer and Over steer, Effect of Tire Camber and Vehicle Roll (3 DOF steady-state model), Transient Handling and Directional Stability (2 DOF unsteady model), Effect of Vehicle Roll on Transient Handling (3DOFunsteadymodel),Steady-StateandTransientHandlingofArticulatedVehicles..

Learning outcomes:

After Completion of this unit, students will be able to

- ***explain*** the Steering Geometry (L2)
- ***understand*** Effect of Vehicle Roll on Articulated Vehicles(L2)

Text Books

1. Hans Pacejka, Tireand Vehicle Dynamics, Elsevier.
2. Thomas D Gillespie, "Fundamentals of Vehicle dynamics ",SAEUSA.
3. Rajesh Rajamani, Vehicle Dynamics& control, Springer.

Reference Books

1. R.V.Dukkipati, Vehicle dynamics, Narsova Publications.
2. Wong JY, "Theory of Ground Vehicles ",John Wiley& Sons, NewYork,.
3. Milliken WF and Milliken DL, Race car Vehicle Dynamics, SAE.
4. Garrett TK, Newton K and Steeds W, "Motor Vehicle", Butter Worths &Co., Publishers Ltd., New Delhi.
5. Heinz Heister, "Vehicle and Engine Technology", SAE Second Edition,.
6. Vittore Cossalter, Motorcycle Dynamics, 2nd Edition, Publisher: LULU.com
7. RN Jazar, Vehicle Dynamics: Theory and Application, Springer.

Code	Subject Name	L	T	P	C
ME-MD1204.4	Optimization and Reliability **(Elective-III)**	3	0	0	3

Course Objectives:

The objectives of the course are to

- Familiarize basic concepts of classical optimization techniques.
- Explain numerical methods for optimization.
- Formulate mathematical model for problem solving.
- Apply the Concept of reliability to engineering systems.

Course Outcomes:..

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

- ***solve*** Single variable, multi – variable optimization problems(L3)
- ***develop*** mathematical models for optimization(L3)
- ***apply*** the conditions for optimizing the non-linear programming problems(L3)
- ***compute*** the optimal values with Numerical Methods (L3)
- ***apply*** reliability concepts in design of engineering systems.(L3)

Unit-I

Introduction to Optimization and Classical Optimization Techniques: Basic Concepts and introduction of engineering optimization, single-variable optimization, Multivariable optimization with no constraints, equality constraints and inequality constraints. exercises, merits and demerits of classical optimization techniques.

Learning outcomes:

At the end of the unit, student will be able to

- ***understand*** classical Optimization Techniques.(L2)
- ***calculate*** optimal values of functions .(L3)

Unit-II

Linear Programming: Basic concepts of Linear programming, Applications of Linear programming, Formulation of Linear programming problems, solution methods for two variable and three variable problems , Integer Programming

Learning outcomes:

At the end of the unit, student will be able to

- ***explain*** the methods to solve two variable and three variable problems.(L2)
- ***solve*** Integer Programming problems.(L3)

Unit-III

Non Linear Programming: Basic concepts of Non-linear programming,
Method of Lagrange multipliers, Kuhn-Tucker conditions. classification of unconstrained minimization methods- quadratic programming

Learning outcomes:

At the end of the unit, student will be able to

- ***apply*** Kuhn-Tucker conditions for non-linear programming problem.(L3)
- ***solve*** quadratic programming problem (L3)

Unit–IV

Numerical Methods for Optimization: Direct search methods, Indirect search methods, characteristics of a constrained problem-Direct methods, Indirect methods.
Gradient of a function, Steepest descent method, Newton's method, advantages of numerical methods.

Learning outcomes:

At the end of the unit, student will be able to

- ***compute*** optimal value with search methods.(L2)
- ***understand*** the applications of numerical methods.(L3)

Unit V

Reliability: Concepts of reliability, bath tub curve, failure rate, MTBF, risk and reliability, reliability of series systems, parallel systems, reliability with time span, probabilistic approach to reliability, reliability theory ,design for reliability, methods to improve reliability of the system, numerical problems,

Learning outcomes:

At the end of the unit, student will be able to

- ***understand*** the failure rate curve for reliability computations (L2)
- ***explain*** the methods to improve the reliability of the system.(L2)

Text Books

1. Optimization for Engineering Design–Kalyanmoy Deb, PHI Publishers
2. Engineering Optimization–S.S.Rao, New Age Publishers
3. Reliability Engineering by L.S.Srinath
4. Multi objective genetic algorithm by Kalyanmoy Deb, PHI Publishers.

References

2. Genetic algorithms in Search, Optimization, and Machine learning–D.E. Goldberg, Addison-Wesley Publishers
3. Multi objective Genetic algorithms- Kalyanmoy Deb, PHI Publishers
4. Optimal design– Jasbir Arora, McGraw Hill (International)Publishers
5. An Introduction to Reliability and Maintainability Engineering by CEE beling, Wavel and Printers Inc.
6. Reliability Theory and Practiceby IBazovsky, Dover Publications

Code	Subject Name	L	T	P	C
ME-MD1205.1	Pressure Vessel Design **(Elective- IV)**	3	0	0	3

Course objectives:

The objectives of the course are to

- Teach the Materials- shapes of Vessels- stresses in cylindrical
- Introduce Theory of thick cylinders
- Teach the Pure bending- different edge conditions
- Teach cylindrical vessel under axially symmetrical loading,

Course outcomes

At the end of the Course, the student will be able to

- ***explain*** the bending and torque for computation of pressure vessels-conical and tetrahedral vessels(L2)
- ***design*** of dome bends, shell connections, flat heads and cone openings.(L6)
- ***understand*** the Pure bending-different edge conditions(L2)
- ***explain*** techniques of discontinuity stresses in pressure vessels(L2)
- ***understand*** the pressure vessel materials and their environment.(L2)

Unit–I

Introduction: Materials- shapes of Vessels- stresses in cylindrical, spherical and arbitrary, shaped shells. Cylindrical Vessels subjected to internal pressure, wind load, bending and torque or computation of pressure vessels-conical and tetrahedral vessels.

Learning outcomes:

At the end of the unit, student will be able to

- ***explain*** the bending and torque for computation of pressure vessels-conical and tetrahedral vessels(L2)

Unit–II

Theory of thick cylinders: Shrink fit stresses in built up cylinders-auto frottage of thick cylinders. Thermal stresses in Pressure Vessels.

Learning outcomes:

At the end of the unit, student will be able to

- ***design*** of dome bends, shell connections, flat heads and cone openings.(L6)

Unit–III

Theory of rectangular plates: Pure bending-different edge conditions.

Theory circular plates: Simple supported and clamped ends subjected to concentrated and uniformly distributed loads-stresses from local loads. Design of dome bends, shell connections, flat heads and cone openings.

Learning outcomes:

At the end of the unit, student will be able to

- ***understand*** the Pure bending- different edge conditions(L2)

Unit–IV

Discontinuity stresses in pressure vessels: Introduction, beam on an elastic foundation, infinitely long beam, semi infinite beam, cylindrical vessel under axially symmetrical loading, extent and significance of load deformations on pressure vessels, discontinuity stresses in vessels, stresses in a bimetallic joints, deformation and stresses in flanges.

Learning outcomes:

At the end of the unit, student will be able to

- ***explain*** techniques of discontinuity stresses in pressure vessels(L2)

Unit–V

Pressure vessel materials and their environment: Introduction, ductile material tensile tests, structure and strength of steel, Leuder's lines, determination of stress patterns from plastic flow observations, behaviour of steel beyond the yield point, effect of cold work or strain hardening on the physical properties of pressure vessel steels, fracture types in tension, toughness of materials, effect of neutron irradiation of steels, fatigue of metals, fatigue crack growth, fatigue life prediction, cumulative fatigue damage, stress theory of failure of vessels subject to steady state and fatigue conditions.

Learning outcomes:

At the end of the unit, student will be able to

- ***understand*** the pressure vessel materials and their environment.(L2)

Text Books

1. Theory and design of modern Pressure Vessels by John F.Harvey, Vannostrandrei hold company, NewYork.
2. Pressure Vessel Design and Analysis by Bickell, M.B.Ruizcs.

References

1. Process Equipment design- Beowll & YoundEtt.
2. Indian standard code for unfired Pressure vessels IS:2825.
3. Pressure Vessel Design HandBook, Henry H.Bednar, P.E.,C.B.S. Publishers, NewDelhi.
4. Theory of plates and shells-Timoshenko & Noinosky.

Code	Subject Name	L	T	P	C
ME-MD1205.2	Mechanics of Composite Materials **(Elective-IV)**	3	0	0	3

Course Objective:

The objectives of the course are to

- Formulate the Relationship between Stress& Strain for any material
- Analyze Macro mechanically on a lamina related to 2 dimensional objects
- Analyze Macro mechanically on a lamina related to 3dimensional objects
- Understand the effects of Laminates

Course outcomes:

After completion of this unit, students will be able to

1. ***understand*** about composites and its classification**(L1)**
2. ***explain*** the Relationship between Stress& Strain(**L2)**
3. ***analyze*** Macro mechanically on a lamina related to2 dimensions**(L4)**
4. ***analyze*** Macro mechanically on a lamina related to 3dimensions**(L4)**
5. ***design*** of Laminates**(L6)**

Unit–I

Introduction to Composites: Introduction, Classification, matrix materials, reinforced matrix of composites

Application: Construction & Material optimization on Mechanical components

Learning outcomes:

After completion of this unit, students will be able to

- ***understand*** the concept of composite materials (L4)

Unit–II

Hooke's Law for a Two-Dimensional Angle Lamina, Engineering Constants of an Angle Lamina, Invariant Form of Stiffness and Compliance Matrices for an Angle Lamina Strength Failure Theories of an Angle Lamina: Maximum Stress Failure Theory Strength Ratio, Failure Envelopes, Maximum Strain Failure Theory ,Tsai–Hill Failure Theory, Tsai–Wu Failure Theory, Comparison of Experimental Results with Failure Theories. Hygrothermal Stresses and Strains in a Lamina: Hygrothermal Stress–Strain Relationships for a Unidirectional Lamina, Hygrothermal Stress–Strain Relationships for an Angle Lamina

Application: Construction & Material optimization on Mechanical components

Learning outcomes:

After completion of this unit, students will be able to

- ***analyze*** Hooke's Law for a Two-Dimensional Angle Lamina (L4)

Unit–III

Macro mechanical Analysis of a Lamina :Introduction ,Definitions: Stress, Strain ,Elastic Moduli, Strain Energy. Hooke's Law for Different Types of Materials, Hooke's Law for a Two-Dimensional Unidirectional Lamina, Plane Stress Assumption, Reduction of Hooke's Law in Three Dimensions to Two Dimensions, Relationship of Compliance and Stiffness Matrix to Engineering Elastic Constants of a Lamina,

Application: Material optimization on planes.

Learning outcomes:

After completion of this unit, students will be able to

- ***analyze*** Macro mechanically on a lamina (L4)
- ***understand*** the Plane Stress Assumption (L2)

Unit–IV

Micro mechanical Analysis of a Lamina: Introduction, Volume and Mass Fractions, Density, and Void Content, Evaluation of the Four Elastic Moduli, Strength of Materials Approach, Semi-Empirical Models ,Elasticity Approach, Elastic Moduli of Lamina with Transversely Isotropic Fibers, Ultimate Strengths of a Unidirectional Lamina, Coefficients of Thermal Expansion, Coefficients of Moisture Expansion

Macro mechanical Analysis of Laminates: Introduction, Laminate Code, Stress–Strain Relations for a Laminate, In-Plane and Flexural Modulus of a Laminate, Hygro thermal Effects in a Laminate, War page of Laminates, hybrid laminates

Application: Construction & Material optimization on Mechanical components

Learning outcomes:

After completion of this unit, students will be able to

- ***analyze*** Macro mechanically on a lamina (L4)
- ***understand*** the effects of Laminates (L2)

Unit–V

Design of Laminates : Introduction , thin plate theory, specially orthotropic plate, cross and angle ply laminated plates, problems using thin plate theory, Failure Criterion for a Laminate, Design of a Laminated Composites.

Application: Construction & Material optimization on Mechanical components

Learning outcomes:

After completion of this unit, students will be able to

- ***formulate*** the Relationship between stress& Strain for any material(L3)
- ***analyze*** Macro mechanically on a lamina related to 2 dimensional objects (L4)
- ***analyze*** Macro mechanically on a lamina related to 3 dimensional objects (L4)
- ***understand*** the effects of Laminates (L2)

Text Books

1. Engineering Mechanics of Composite Materials by Isaac and MDaniel, Oxford University Press.
2. B.D.Agarwal and L.J.Broutman, Analysis and performance of fibre Composites, Wiley-Interscience, NewYork.
3. Mechanics of Composite Materials, Second Edition (Mechanical Engineering), By AutarK.Kaw, Publisher:CRC

References

1. R.M.Jones, Mechanics of Composite Materials, McGraw Hill Company, NewYork,.
2. L.R.Calcote, Analysis of Laminated Composite Structures, VanNostr and Rainfold, New York.

Code	Subject Name	L	T	P	C
ME-MD1205.3	Theory of Plasticity **(Elective-IV)**	3	0	0	3

Course Objectives:

The objectives of the course are

- To familiarize the principal stresses and strains.
- To know yield criteria and concept of failure.

Course Outcomes:

At the end of the course students will be able to

1. ***evaluate*** the basic concepts of failure criteria stress.(L3)
2. ***evaluate*** the different Yield criteria. (L3)
3. ***explain*** the general Isotropic materials.(L2)
4. ***explain*** deformation theory of plasticity under various loads.(L2)
5. ***solve*** the Numerical algorithms for solving non linear equations(L3)

Unit–I

Introduction: Modeling Uniaxial behavior in plasticity. Index notation, Cartesian tensors. Yield and failure criteria Stress, stress deviator tensors. Invariants, principal, mean stresses. Elastic strain energy. Mohr's representation of stress in 2 & 3 dimensions. Haigh-Westergaard stress space. Equilibrium equations of a body. Yield criteria: Tresca's, von Mises rules, Drucker-Prager criterion, an isotropic yield criteria.

Strain at point: Cauchy's formulae for strains, principal strains, principal shear strains, derivative strain tensor. Strain-displacement relationships. Linear elastic stress strain relations, Generalized Hooke's law, non linear elastic stress strain relations.

Learning outcomes:

At the end of this unit, the student will be able to

- ***explain*** uniaixal behavior in plasticity.(L2)
- ***summarize*** the basic concepts of failure criteria stress.(L2)

Unit–II

Principle of virtual work and its rate forms: Drucker's stability postulate, normality, convexity and uniqueness for an elastic solid. Incremental stress strain relations.

Criteria for loading and unloading: Elastic and plastic strain increment tensors, Plastic potential and flow rule associated with different Yield criteria, Convexity, normality and uniqueness considerations for elastic–plastic materials. Expansion of a thick walled cylinder.

Learning outcomes:

At the end of this unit, the student will be able to

- ***explain*** Drucker's stability postulate.(L2)
- ***explain*** the criteria for loading and unloading.(L2)

Unit–III

Incremental stress strain relationships: Prandtl- Reuss material model. J_2deformation theory,Drucker- Prager material, General Isotropic materials.

Deformation theory of plasticity: Loading surface, Hardening rules. Flow rule and Druckers stability postulate. Concept of effective stress and effective strain, mixed hardening material. Problems.

Learning outcomes:

At the end of this unit, the student will be able to

- ***explain*** deformation theory of plasticity under various loads.(L2)
- ***explain*** the general Isotropic materials.(L2)

Unit–IV

Finite element formulation for an elastic plastic matrix: Numerical algorithms for solving non linear equations, Convergence criteria, Numerical implementations of the elastic plastic incremental constitutive relations.

Learning outcomes:

At the end of this unit, he student will be able to

- ***explain*** the finite element formulation for an elastic plastic matrix.(L2)

Unit–V

Bounding surface theory: Uniaxial and multi axial loading an isotropic material behavior Theroms of limit analysis: Statically admissible stress field and kinematically admissible velocity field. Upper and lower bound theorms, examples and problems.

Learning outcomes:

At the end of this unit, the student will be able to

- ***explain*** the thermos of limit analysis.(L2)

Text Book

1.Plasticity for structural engineering W.F.Chens andD.J.Han,Springerverlag-1987.

References

1. Mechanics of Materials–II, Victor E. Saouma.
2. Theory of plasticity, Sadhu Singh

.

Code	Subject Name	L	T	P	C
ME-MD1205.4	Design with advanced materials **(Elective-IV)**	3	0	0	3

Course Objectives:

The objectives of the course are

- To know the fundamentals of material science.
- To understand the motivation of selection of materials on the cost basis and service requirements.
- To know the fundamentals of modern metallic Materials.
- To know the fundamentals of Non metallic materials.
- To understand the fundamentals of Smart materials.

Course Outcomes:

At the end of the course students will be able to

1. ***understand*** the fundamentals of material science.(L2)
2. ***analyze*** the use of material property charts for material selection.(L4)
3. ***understand*** the fundamentals of modern metallic materials. (L2)
4. ***understand*** the fundamentals of non modern metallic materials. (L2)
5. ***explain*** the fundamentals of Smart materials. (L2)

UNIT–I

Fundamentals of material science: Elasticity in metals and polymers, mechanism of plastic deformation, role of dislocations, yield stress, shear strength of perfect and real crystals, strengthening mechanism, work hardening, solid solution, grain boundary strengthening.

Poly phase mixture, precipitation, particle, fiber and dispersion strengthening, effect of temperature, strain and strain rate on plastic behavior, super plasticity, deformation of non crystalline material.

Learning outcomes:

At the end of this unit, he student will be able to

- ***explain*** the mechanism of plastic deformation in materials. (L2)
- ***explain*** the effect of temperature, strain and strain rate on plastic behavior. (L2)

UNIT–II

Motivation of selection, cost basis and service requirements, selection for mechanical properties, strength, toughness, fatigue and creep, use of material property charts for material selection.

Learning outcomes:

At the end of this unit, he student will be able to

- ***explain*** the cost basis and service requirements while selecting the materials. (L2)
- ***explain*** the effect of temperature, strain and strain rate on plastic behavior. (L2)

UNIT–III

Modern metallic Materials: Dual phase steels, micro alloyed, high strength low alloy (HSLA) Steel, maraging steel, intermetalics ,Ni and Ti aluminides, super alloys.

Learning outcomes:

At the end of this unit, he student will be able to

- ***explain*** the Dual phase steels. (L2)
- ***explain*** the behavior super alloys. (L2)

UNIT–IV

Non metallic materials: Polymeric materials and their molecular structures, production techniques for fibers, foams, adhesives and coatings, structure, properties and applications of engineering polymers. composites; Introduction, reinforcement, types of composite materials, - properties, processing and application of composite materials.

Learning outcomes:

At the end of this unit, he student will be able to

- ***understand*** the Polymeric materials and their molecular structures. (L2)

UNIT–V

Smart materials, shape memory alloys, metallic glass, quasi crystal and nano crystalline materials.

Learning outcomes:

At the end of this unit, he student will be able to

- ***explain*** the functions of Smart materials. (L2)
- ***understand*** the concept of nano crystalline materials. (L2)

TEXTBOOKS:

1. Mechanical behavior of materials/Thomas H. Courtney /2nd Edition,McGraw-Hill,2000
2. Mechanical Metallurgy/George E. Dieter/McGraw Hill
3. Material selection in mechanical design by M.F Ash by .Bott

REFERENCES:

Selection and use of Engineering Materials 3e/Charles J.A/Butterworth Heiremann

Code	Subject Name	L	T	P	C
ME-MD1206	Computational Mathematics Laboratory	0	0	4	2

Course Outcomes:

The outcomes of the lab are

1. ***solve*** Problems of Engineering by writing programs in MATLAB and Python code.
2. ***performing*** Numerical method and obtaining the solution for the statements using MATLAB and Python code.
3. ***solve*** Problems of Matrices and Eigen values by writing programs in MATLAB and Python code.
4. ***generate*** MATLAB and Python code for Different methods to solve differential equations.
5. ***generate*** MATLAB and Python code for Different methods to solve Fourier transformation.

LIST OF EXPERIMENT

1. Generate a MATLAB and Python code for solving a system of linear equation using Gauss Elimination Method.
2. Generate a MATLAB and Python code for LU Decomposition(Factorization)
3. Generate a MATLAB and Python code for Iterative methods to solve equations using Jacobi Iteration.
4. Generate a MATLAB and Python code for Curve fitting
    i. Straight line fit
    ii. Polynomial Curve fit
5. Generate a MATLAB and Python code for Fourier transformation
    i. FFTVs DFT
    ii. Interpolation by DFS
6. Generate a MATLAB and Python code for Euler's method differential equations
7. Generate a MATLAB and Python code for Runge– Kutta method differential equations
8. Generate a MATLAB and Python code for Matrices and Eigen values
    i. Eigen values and Eigen vectors
    ii. Jacobi method
9. Generate a MATLAB and Python code for Partial Differential equations
    i. Elliptical PDE
    ii. Parabolic PDE
    iii. The Crank–Nicholson method
    iv. Two dimensional parabolic PDE

Code	Subject Name	L	T	P	C
ME-MD1207	Advanced Computer aided analysis Laboratory	0	0	4	2

Course Objectives:

The objectives of the lab are to

1. To provide a comprehensive knowledge of various CAD Tools.
2. To provide comprehensive hands-on experience in computer-based modelling, analysis and design of mechanical components and systems with a multi-disciplinary approach.
3. To expose to CAD tools such as CATIA, ANSYS, HYPERMESH for use in mechanical engineering applications software and analyzing engineering problems
4. To familiarize the techniques of Finite element formulations for various mechanical Egg problems and apply them on CAD related problems

Course Outcomes:

At the completion of the course, the student will be able to

1. ***identify*** various CAD peripherals and learn concepts of various space curves (L3)
2. ***demonstrate*** how to draw different geometric models (wire frame, surface) with various CAD Tools.(L2)
3. ***develop*** computer-based software methods to mechanical design and solid modelling(L3)
4. ***apply*** knowledge of design engineering computer tools to provide solutions to complex engineering problemsor to do research in the areas of Design and simulation in Mechanical Engineering.(L3)
5. ***design*** and validate technological solutions to defined problems and communicate clearly and effectively for the practical application.(L6)

Note: Conduct any Ten exercises from the list given below:

1. Analysis of Framed structures using FEA software.

2. Perform Fracture analysis for simple problem using FEA software.

3. Analysis of laminated composite structures using FEA software.

4. Perform a simple modal analysis for a cantilever beam using FEA software.

5. Perform Harmonic analysis for a given cantilever beam using FEA.

6. Perform a simple transient analysis for different beams.

7. **Non Linear Analysis:** Find the geometric non linearity behavior for a cantilever beam subjected to a large moment.

8. **Buckling analysis:** Solve simple buckling problems using Eigen value and non linear methods

9. Stress analysis of a rectangular plate with a circular hole.

10. Thermal Analysis of 1D & 2D problem with conduction and convection boundary conditions. (Minimum 4 exercises)

11. Design optimization of unknown parameters for a given beam.

12. Use of contact elements to simulate two given beams when they are in contact with each other.

13. **Flow Over a Flat Plate:** Solve a classical flat plate 2-D air flow problem

14. **Using Coupled Structural/Thermal Analysis:** solve a simple structural/thermal problems

15. **Sub-structuring**: Solve a simple problems using Sub-structuring method in ANSYS.

16. **Melting Using Element Death**: Using element death procedure model melting of a material.

II Year–I Semester

Code	Subject Name	L	T	P	C
ME-MD2103	English for Research Paper Writing	2	0	0	0

Course Objectives:

The objectives of the course are to

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

Course Outcomes:

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

1. ***develop*** a writing skills by analyzing model texts (written by 'expert' writers) and xts written by students (with particular focus on issues involving coherence and cohesion); (L3)
2. ***explain*** the academic vocabulary;(L2)
3. ***identify*** the more advanced aspects of English grammar relevant to writing research papers; (L3)
4. ***understand*** the language functions found in research papers; (L2)
5. ***compare*** various practices and conventions used in writing research papers across arrange of disciplines. (L4)

Unit I

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

Learning outcomes:

At the end of the unit, student will be able to

- ***develop*** the ability of Planning and Preparation, Word Order and Breaking up long sentences (L3)

Unit II

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction

Learning outcomes:

At the end of the unit, student will be able to

- ***understand*** the concept of Paraphrasing and Plagiarism (L2)

Unit III

Review of the Literature, Methods, Results, Discussion, Conclusions, the Final Check.

Learning outcomes:

At the end of the unit, student will be able to

- ***understand*** the concept of Literature review.(L2)

Unit IV

key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature,

Learning outcomes:

At the end of the unit, student will be able to

- ***identify*** the key skills are needed when writing a Title.(L3)

Unit V

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions useful phrases, how to ensure paper is as good as it could possibly be the first-time submission

Learning outcomes:

At the end of the unit, student will be able to

- ***identify*** the key Skills are needed when writing the Methods.(L3)

Textbooks

2. Goldbort R Writing for Science, Yale University Press (available on Google Books)
3. Day RHow to Write and Publish a Scientific Paper, Cambridge University Press
4. Highman N , Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book.
5. Adrian Wall work, English for Writing Research Papers, Springer New York Dordrecht Heidelberg London.

Subject Code	Subject Name	L	P	Credits
ME-MD2104	Research Methodology and IPR	2	0	2

Course Objectives:

The objectives of the course are to

- Introduce the research problem formulation.
- Learn research related information Follow research ethics
- Introduce the when IPR would take such important place in growth of individuals &nation, it is needless to emphasise the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
- Introduce the IPR protection provides an incentive to inventors for further research work and investment in R&D.

Course Outcomes:

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

1. ***understand*** research problem formulation.(L2)
2. Analyze research related information and Follow research ethics.(L4)
3. ***understand*** that today's world is controlled by Computer, Information Technology, bottom or row world will be ruled by ideas, concept, and creativity.(L2)
4. ***understand*** that when IPR would take such important place in growth of individuals &nation, it is needless to emphasise the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.(L2)
5. ***understand*** that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.(L2)

Unit I

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Learning outcomes:

At the end of this unit, the student will be able to

- ***understand*** the sources of research problem.(L2)

Unit II

Effective literature studies approaches, analysis Plagiarism, Researchethics.

Learning outcomes:

At the end of this unit, the student will be able to

- ***analyze*** effective literature studies.(L4)

Unit III

Effective technical writing, how to write report, Paper, Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.

Learning outcomes:

At the end of this unit, the student will be able to

- ***understand*** the Effective technical writing.(L2)

Unit IV

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Learning outcomes:

At the end of this unit, the student will be able to

- ***understand*** the process of patenting.(L2)
- ***understand*** the procedure for grants of patents, Patenting under PCT (L2).

Unit V

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Learning outcomes:

At the end of this unit, the student will be able to

- ***explain*** the scope of patent rights the process of patenting.(L2)

References

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science &engineering students'"
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
3. Ranjit Kumar,2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
4. Halbert, "Resisting Intellectual Property", Taylor& Francis Ltd.
5. Mayall, "Industrial Design", McGraw Hill.
6. Niebel,"Product Design",McGraw Hill.
7. Asimov, "Introduction to Design" ,Prentice Hall.
8. Robert P.Merges, Peter S. Menell, MarkA. Lemley, "Intellectual Property in New Technological Age".
9. T.Ramappa, "Intellectual Property Rights Un