BansilalRamnathAgarwal Charitable Trust's

Vishwakarma Institute of Technology

(*An Autonomous Institute affiliated to University of Pune*)

Structure and Syllabus of

M.E. (Mechanical – Design Engineering)

Pattern A-13

Effective from Academic Year 2013-14

Prepared by: - Board of Studies in Mechanical Engineering

Approved by: - Academic Board, Vishwakarma Institute of Technology, Pune

Signed by,

Chairman – BOS **Chairman – Academic Board**

Contents

Semester – I

STRUCTURE – SEMESTER I

Subject Code	Subject Name	Type	Teaching scheme (Hrs./week)		Assessment scheme					Credits
					ISA#				ESA	
			Lect.	Practical	CT*	MSE	HA	CA	ESE	
Semester –I										
ME50101	Mathematical Methods in Mech. Engg.	Theory	3	-	10	30	10	-	50	3
ME50102	Advanced Stress Analysis	Theory	3	-	10	30	10	-	50	3
ME50103	Vibration and Noise Control	Theory	3	-	10	30	10	-	50	3
Elective I		Theory	3	-	10	30	10	-	50	3
ME52101	Reliability Engineering									
ME52102	Advanced Manufacturing Methods									
ME50107	Thermofluids-I									
Elective II		Theory	3	-	10	30	10	-	50	3
ME52103	Analysis and Synthesis of Mechanisms									
ME52104	Process Equipment Design									
ME52105	Industrial Tribology									
ME50301	Design Engg. Lab-I	Lab	-	4	-	-	-	100	-	4
HS56301	Communication & Soft Skill	Lab	-	2	-	-	-	-	100	2
ME50401	CVV-I	Oral	-	-	-	-	-	-	100	2
ME57702	Semester Project-I	Project	-	6	-	-	-	-	100	2
	Total		**15**	**12**						**25**

***** CT (Unit 1) 1 hour 30 marks converted to 10 marks + HA (minimum 3) – Total 30 marks converted to 10 marks = 20 marks

MSE – 2 hours 60 marks converted to 30 marks (Unit 2 & 3), ESE – 3 hours 100 marks converted to 50 marks (Unit 1 to 6)

\# ISA – In Semester Assessment, ESA – End Semester Assessment, CT- Class Test,

MSE – Mid Semester Examination, HA- Home Assignment, CA – Continuous Assessment, ESE – End Semester Examination

ME50101: Mathematical Methods in Mechanical Engineering

Credits: 03 Teaching Scheme: 3 hrs / Week

Course Objectives:-

i. The students will have a thorough knowledge of the mathematical methods to be applied to problems in Mechanical Engineering.

Course Outcomes:

i. Students develop an in-depth knowledge of numerical methods applicable for mechanical engineering
ii. Students develop the ability to formulate and to obtain the numerical solution of mechanical engineering problems
iii. Students will be able to compare different numerical schemes
iv. Students will be able to understand the algorithms of mechanical engineering related software packages

Unit I

Linear Algebra **(10Hrs.)**

Classical theory, Direct methods – LU, SVD, Iterative Methods- Gauss Siedel, tridiagonal systems, eigenvalues, maximum and minimum eigenvalues, applications

Unit II

Interpolation **(2 Hrs.)**

Splines – Quadratic and Cubic Splines, applications

Unit III

Nonlinear system **(3 Hrs.)**

Newton Method for nonlinear systems, applications to engineering systems

Unit IV

Ordinary Differential equations (8Hrs.)

Linear systems, classical methods, adaptive numerical methods, implicit methods for stiff systems.

Unit V

Variational Methods (5Hrs.)

Energy Methods: Rayleigh-Ritz and Galerkin methods, Introduction to FEM – application to one dimensional boundary value problems

Unit VI

Partial Differential Equations (12Hrs.)

Elliptic equations- classical and iterative methods, Parabolic Equations – classical and numerical methods; Hyperbolic Equations – analytical and numerical methods

Total Contact Hours: 40

Reference Books:

1. Numerical Methods for scientific and engineering computation: MK Jain, SRK Iyengar and RK Jain.
2. Mathematics of Physics and Engineering: IS Sokolnikoff and RM Redheffer.

ME50102 : ADVANCED STRESS ANALYSIS

Credits: 03 **Teaching Scheme: 3 hrs / Week**

Objectives

1. To introduce to students the Concept of three dimensional stress and strain at a point as well stress-strain relationships for isotropic materials.

2. To introduce to students the method of calculation of stresses in components of noncircular cross section subjected to unsymmetrical bending and torsional loading.

3. To introduce to students the method of calculation of shear stress in thin walled sections and determination of shear center.

4. To introduce to students the method of calculation of stresses and strains associated with thick wall cylindrical pressure vessels and rotating disks.

5. To introduce to student the methods of computing contact stresses and deflections

Outcomes :

1. Students will be able to apply the mechanics of materials methods to engineering problems to understand structural responses to various loading conditions.
2. Students will be able to formulate solutions to solid mechanics problems.
3. Students will be able to comprehend current research findings as reported in journals in the field of solid mechanics

Unit 1 Theory of elasticity **(6 Hrs.)**

Plane stress & Plane strain, Two dimensional problems in Rectangular & Polar co-ordinate system, Analysis of stresses & strains in three dimension.

Unit 2 Theory of torsion **(6 Hrs.)**

Torsion of general prismatic bars of solid section, Membrane Analogy, Torsion of Thin walled tubes,

Torsion of Thin walled Multiple-Cell closed sections, Torsion of rolled sections

Unit 3 Bending of Prismatic bars, Unsymmetric and Plastic bending (8 Hrs.)

Concept of shear centre in symmetrical and unsymmetrical bending, stress and deflections in beams subjected to unsymmetrical bending, shear center for thin wall beam cross section, open section with one axis of symmetry, general open section and closed section.

The plastic flow process, shape factor, springback, plastic bending with strain hardening material, plastic hinges, plastic deflection.

Unit 4 Plate Bending (6 Hrs.)

Bending of plate to cylindrical surface, Bending of a long uniformly loaded rectangular plate, pure bending in two perpendicular directions, Bending of circular plates loaded symmetrically w.r.t. center. Circular plate with circular hole at center symmetrically loaded & load distributed along inner & outer edges, Bending of circular plates of variable thickness.

Unit 5 Pressurized Cylinders & Rotating Disks (8 Hrs.)

Governing equations, stresses in thick walled cylinder under internal & external pressure, shrink fit compound cylinders, stresses in rotating flat solid disk, flat disk with central hole, disk with variable thickness, disk of uniform strength.

Unit 6 Contact Stresses (6Hrs)

Geometry of contact surfaces, methods of computing contact stresses and deflection of bodies in point contact, stress for two bodies in line contact with load normal to contact area and load normal and tangent to contact area. Introduction to analysis of low speed impact.

Total Contact Hours: 40

Text Books :

1. Advanced strength and Applied stress analysis - Richard G Budynas, McGraw Hill
2. Advanced Mechanics of solids - L S Srinath , McGraw Hill

Reference Books

1. Advanced Mechanics of Materials - Cook and Young , Prentice Hall
2. Theory of elasticity - Timoshenko and Goodier , McGraw Hill
3. Advance Strength of Materials- vol 1 & 2 – Timoshenko, CBS publisher
4. Advanced Mechanics of Materials – Boresi, Schmidt, Sidebottom, Willey
5. Mechanics of Materials - vol 1 & 2 - E J Hearn , Butterworth- Heinemann

ME50103 : Vibrations and Noise Control

Credits: 03 Teaching Scheme: 3 hrs / Week

Course Objectives:

i. To enable students to solve field problems and applications

ii. To enable students to appreciate the computational and analytical procedures used the design of vibration equipments.

Course Outcomes:

- **i.** To develop in our students the ability to engage themselves to solve vibration problems.
- **ii.** To be creative problem solvers whilst dealing with machinery involving periodic phenomena
- **iii.** To integrate empirical analysis and add to the world of field expertise where possible
- **iv.** To adapt to recent advances in knowledge

Unit 1 : Transient Vibrations (6 Hrs)

Response of a single degree of freedom system to step and any arbitrary excitation, convolution (Duhamel's) integral, impulse response function.

Unit 2 : Multi degree of freedom systems (8 Hrs)

Free, damped and forced vibrations of two degree of freedom systems, beat phenomenon, multi degree of freedom systems, matrix formulation, stiffness and flexibility influence coefficients, Eigen values and Eigen vectors, normal modes and their properties, mode summation method, use of Lagrange's equations to derive the equations of motion.

Unit 3 : Continuous Systems (8 Hrs)

Vibrations of strings, bars, shafts and beams, discredited models of continuous systems and their solutions using Rayleigh – Ritz and Galerkin methods, use of Lagrange's equation. Mode summation method.

Unit 4 : Vibration and Shock Control (6 Hrs)

Methods of vibration control, undamped / damped vibration absorbers, vibration dampers and isolators. Helmet design fundamentals.

Unit 5 : Self-excited vibrations (4 Hrs)

Only introduction, examples of self-excited vibrations like tool-chatter phenomenon, etc

Unit 6 : Introduction to Shock and Noise (8 Hrs)

Nonlinear vibrations, random vibrations. Theory of sound and noise Fundamentals of Noise measurement. Noise control and pollution norms. Noise free environment design.

Total Contact Hours: 40

Text Books:

1. Theory of vibrations with applications: W.T. Thomson, CBS Publishers, Delhi.

2) Mechanical Vibrations: S.S. Rao, Addison – Wesley Publishing Co.

Reference Books:

1) Fundamentals of vibrations: Leonard Meirovitch, McGraw Hill International Edition.

2) Principles of Vibration Control: Asok Kumar Mallik, Affiliated East-West Press.

3) Mechanical Vibrations: A.H.Church, John Wiley and Sons, Inc.

4) Vibrations and Noise Control - By K Pujara

5) Schaum Series Problems in Vibrations

ME52101: Reliability Engineering

Credits: 03 **Teaching Scheme: 3 hrs / Week**

Course Objectives:

i. To summarize reliability engineering and its management throughout the product life cycle.
ii. To perform reliability engineering analysis.
iii. To compute reliability engineering parameters and estimates for applications in mechanical devices and manufacturing environments.

Course Outcomes:

i. Demonstrate understanding of basic reliability measures such as MTTF, MTBF, MTTR, availability, failure rate, Bathtub curve, etc.

ii. Compute and evaluate reliability for redundant, series, and parallel systems

Unit 1: Fundamental concepts:- **(7 Hrs)**

Reliability definitions, failure, Failure density, Failure Rate, Hazard Rate, Mean Time To Failure, MTBF, maintainability, availability , pdf, cdf, safety and reliability, Quality, cost and system effectiveness, Life characteristic phases, modes of failure, Areas of reliability,Quality and reliability assurance rules, product liability, Importance of Reliability,

Unit 2: Probability theory:- **(7 Hrs)**

Set theory, laws of probability, total probability theorem, probability distributions binomial, normal, poisson , lognormal, weibull , exponential, standard deviation, variance, skewness coefficient , chebyshev inequality, central limit theorem.

Unit 3: System reliability and modelling: **(7 Hrs)**

Series, parallel, mixed configuration, k- out of n structure, complex systems- enumeration method, conditional probability method, cut set and tie set method, Redundancy, element redundancy, unit redundancy, standby redundancy- types of stand by redundancy, parallel components single redundancy, multiple redundancy. Markov analysis.

Unit 4: Maintainability and Availability: **(7 Hrs)**

Objectives of maintenance, types of maintenance, Maintainability, factors affecting maintainability, system down time, Availability - Inherent, Achieved and Operational availability, reliability and maintainability trade-off.

Unit 5: System reliability Analysis: (6 Hrs)

Reliability allocation or apportionment, Reliability apportionment techniques – equal apportionment, AGREE, ARINC, feasibility of objectives apportionment, dynamic programming apportionment, Reliability block diagrams and models, Reliability predictions from predicted unreliability, minimum effort method.

Unit 6: Failure Mode, Effects and Criticality Analysis- (6 Hrs)

Failure mode effects analysis, severity/criticality analysis , FMECA examples, RPN, Ishikawa diagram for failure representation , fault tree construction, basic symbols development of functional reliability block diagram, Fau1t tree analysis, fault tree evaluation techniques, minimal cut set method, Delphi methods, Monte carlo evaluation.

Total Contact Hours: 40 Hrs.

Reference Books

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

Text Books:

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

ME52102: Advanced Manufacturing Methods

Credits: 03 Teaching Scheme: 3 hrs / Week

Course Objectives: To know advancements in various conventional and non-conventional manufacturing methods.

Course Outcomes

1. The students will be able to direct the design and implementation of specific technologies and/or processes addressed during the course to a specific organization
2. To increase the efficiency, productivity and profitability of modern manufacturing industry.

Unit 1 : Metal Forming (6 Hrs)

Introduction, Strain, stress, Mohr's circle, Yield criteria, Comparison of yield criteria, work of deformation, deformation theory, Levy Von-Mises flow rules. Forging practices and operations. Slab method of analysis, open die forging pressure and force analysis.

Unit 2 : Laser Based Machining (7 Hrs)

Basics of lasers covering fundamentals of laser operation, their variety, optical components, beam delivery and properties of focused radiation.Components of industrial laser systems, including motion systems and beam delivery systems. Laser materials processing covering the interaction of a laser beam with materials, phase changes produced and why some lasers are better at processing some materials than other lasers. Industrial applications of lasers including laser cutting, laser welding, laser surfacing, laser marking and laser drilling.

Unit 3 : Micro Machining (7 Hrs)

Machining for Micro devices, Various methods of micromachining like Micro EDM, Micro ECM, Ultrasonics, Lithography, Beam machining processes: LBM, IBM, EBM.

Unit 4 : Material Additive Processes (6 Hrs)

Advanced welding processes, Advanced surface coating processes, Rapid prototype manufacturing.

Unit 5 : Measurement systems for Micromachining (8 Hrs)

Fundamentals of measurement, uncertainty of measurement, calibration; Sensors; Non-contact inspection methods: ultrasonic, computer vision, laser-based interferometry, Tactile inspection: Coordinate Measuring Machines (CMM), mechanical arms;

Intelligent systems: components, benefits and applications. Devices, instruments used for micro machined components.

Unit 6 : NC/CNC/DNC Machine (6 Hrs)

Introduction, Components.Part programming languages, recent developments.

Total Contact Hours: 40 Hrs.

Text Books:

1. Fundamentals of Metal Forming processes, B L Juneja, New Age Publishers.

2. Introduction to Micromachining, V K jain, Narosa Publishing House

Reference Books :

1. Mechanical Metallurgy, George E. Dieter, Pearson education Asia.

ME50107: Thermofluids-I

Credits: 03 **Teaching Scheme: 3 hrs / Week**

Objectives:

i. The students will have a thorough knowledge and understanding of fluid flow and convective heat transfer.

Outcomes:

i. The students will be able to understand various types of flows and hat transfer.
ii. They will be able to model various flow and thermal systems.

Unit 1 (7 Hrs)
Governing Equations: of mass, momentum and energy in differential, integral forms; flow kinematics streamlines, vorticity, strain rate etc.

Unit 2 (7 Hrs)
Conduction: steady state and transient; melting and solidification

Unit 3 (6 Hrs)
External fluids: Flow over a flat plate and heat transfer, Other External flows

Unit 4 (7 Hrs)
Internal flows: boundary layer, fully developed flows, heat transfer; introduction to turbulence

Unit 5 (7 Hrs)
Natural convection: governing equations, similarity solutions

Unit 6 (6 Hrs)
Phase-change Convection: boiling and condensation, Nusselt solution

Total Contact Hours: 40

Text Books:

1. Viscous Fluid Flow, FM White - 1991 - McGraw-Hill, Inc., New York

2. Heat conduction, MN Özisik - 1993 - Wiley, New York

3. Fundamentals of aerodynamics, JD Anderson - 2001 - McGraw-Hill, Inc., New York

4. Convective Heat and Mass Transfer, WM Kays, ME Crawford, B Weigand 2004 McGraw-Hill, Inc., New York

Reference Books:

1. Thermal Radiation Heat Transfer R Siegel, JR Howell 1992 Hemisphere Washington DC

2. Boundary Layer Theory H Schlichting, K Gersten 2000 McGraw Hill, New York

ME52103 : Analysis and Synthesis of Mechanisms

Credits: 03 **Teaching Scheme: 3 hrs / Week**

Course Objectives:

1. To study the kinematic analysis and design of mechanisms
2. To apply kinematic theories to synthesize the real-world mechanisms

Course Outcomes:

1. Students will have the confidence to analyze Simple and Complex Mechanisms
2. Students will have the ability to apply kinematic theories to real-world problems of mechanism design and synthesis

Unit I **Introduction:** **(06 Hrs)**

Basic definitions, criterions, degree of freedom, construction of mechanisms, applied mechanisms and equivalent linkages. Mechanical advantage and transmission angle. Review the methods of kinematic analysis. Concept of mechanism synthesis and types.

Unit II **Kinematic Analysis of Complex Mechanisms:** **(07 Hrs)**

Complex mechanisms, degree of complexity, velocity and acceleration analysis of complex mechanisms by normal acceleration method, auxiliary point method and Goodman method.

Unit III **Force Analysis of Planar Mechanisms:** **(06 Hrs)**

Static force analysis, constraint and applied forces, static equilibrium. Dynamic force analysis of planar mechanisms, inertia forces linkages, Kineto-static analysis of mechanisms by matrix method. Analysis of elastic mechanisms, elastic linkage model, equations of motions.

Unit IV **Analytical synthesis of Planar Mechanisms:** **(07 Hrs)**

Type, number and dimensional synthesis, function generation, path generation and rigid body guidance, accuracy (precision) points, Chebychev Spacing, Freudenstein's equation, displacement, velocity and acceleration equations. Synthesis of four-bar function generator and slider- crank mechanism, Complex number method of synthesis. Four and five accuracy point synthesis, errors in linkages.

Unit V **Graphical Synthesis of Planar Mechanisms:** **(07 Hrs)**

Graphical synthesis for function generation, rigid body guidance and path generation. Synthesis with two, three and four accuracy points

using pole method, center point and circle point curves, Branch and order defects, Synthesis of coupler curves, Robert Chebychev theorem, Cognate mechanisms.

Unit VI **Curvature Theory:** **(07 Hrs)**

Fixed and moving centrodes, inflection circle, Euler- Savy equation, Bobillier constructions, cubic of stationary curvature, Ball's point, Applications in dwell Mechanisms

Kinematic Analysis of Spatial Mechanisms :

Denavit- Hartenberg parameters, matrix method of analysis of spatial mechanisms.

Total Contact Hours: 40

Text Books:

1. Theory of Machines and Mechanisms, A. Ghosh and A.K.Mallik, Affiliated East-West Press
2. Theory of Machines and Mechanisms, J. E. Shigleyand J. J. Uicker, 2nd Ed., McGraw-Hill

Reference Books:

1. Kinematic Synthesis of Linkages, R. S. Hartenberg and J. Denavit, McGraw-Hill
2. Mechanism Design - Analysis and Synthesis (Vol.1and 2), A. G. Erdman and G. N. Sandor, Prentice Hall of India
3. Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms and Machines, Robert L.Norton, Tata McGraw-Hill, 3rd Edition.
4. Kinematics and Linkage Design, A.S.Hall, Prentice Hall of India

ME52104 : Process Equipment Design

Credits: 03 Teaching Scheme: 3 hrs / Week

Course Objectives:

i. Understand the content of process flow diagrams (PFD)
ii. Understand the content of piping and instrument diagrams (P&ID)
iii. Introducing students to various design codes
iv. To enable students to apply the requirements of the relevant industry standards to the mechanical design of equipments used in the process industry and above ground atmospheric storage

Course Outcomes:

i. Students will be able to understand the calculation of line sizes and pressure drops , flow measurement sizing and develop a flow measurement process data sheet.
ii. Students will have understanding of several design codes used in the design.
ii. Students will have understanding of the principles of process equipment design, the mechanical aspects of the design and operation of process equipment, including safety considerations.
iv. Students will be able to complete detailed designs of several process equipments.

Unit 1 : Process Design Parameters (7 Hrs)

Basic concepts in process design, block diagrams for flow of processes, material flow balance. Introduction to design codes like IS-2825, ASME-SECT, EIGHT-DIV-II TEMA.API-650, BS-1500 & 1515.

B)Process Control :

Fundamentals of process measurements and control modern control devices and other controls of major unit operation and processes. Applications of CAD to process Equipment Design.

Unit 2 : Design of Cylindrical and Spherical Vessels (7 Hrs)

Thin and thick walled cylinder analysis, design of end closers, local stresses due to discontinuity or change of shape of vessel, vessel opening compensation, design of standard and non-standard flanges, design of vessels and pipes under external pressure, design of supports for process vessels.

Unit 3 : Design of Tall Vessels and Large Storage Tanks (7 Hrs)

Determination of equivalent stress under combined loadings including seismic and wind loads application of it to vertical equipment like distillation column.

Unit 4 : Process Equipment Design (7 Hrs)

Storage vessels, reaction vessels, agitation and mixers, heat exchangers, filters and driers, centrifuges. Code practices, selection and specification procedures used in design. Selection of pumps, compressors, electrical equipments and auxiliary services, safety, etc.

Unit 5 : Process Piping Design (6 Hrs)

Flow diagrams and pipe work symbols, design of layout of water, steam and compressed air pipes work, pipe fitting, linings and flanged connections. Types of valves used on pipe line. Fabrication of pipe lines, expansion joints and pipe supports.

Unit 6 : (6 Hrs)

Planning, manufacture, inspection and erection of process equipment like pressure vessels, chimneys, ducting, heat exchangers, pulverising equipment, etc. protective coatings, lining of vessels.

Total Contact Hours: 40 Hrs.

Text Books:

1) Process Equipment Design : By Dr. M.V. Joshi, Mc-Millan.
2) Process Equipment Design : By Browell and Young, John Wiley.
3) Plant Design and Economics : Max and Timasulaus Kalus – McGraw Hill.
4) Industrial Instrumentation servicing Hand Book : Cannel Grady, McGraw Hill.

Reference Books :

1) Handbook of Instrumentation and Control : Kellen Heward, McGraw Hill.

2) Chemical Engineering Handbook : Perry John, McGraw Hill.

3) Chemical Equipment Design : B.C. Bhattacharya.

4) Industrial Pipe Work : D.N.W. Kentish, McGraw Hill.

5) Chemical Engineering : J.M. Coulson, Richardson, Sinnott Vol. VII, Maxwell, McMillan.

6) Pressure Vessel Design Hand Book : H. Bedna.

7) Dryden's outlines of Chemical Technology for the 2 : By Roa M. Gopala, Sitting M., East West Press Pvt. Ltd., New Delhi.

8) Applied Process Design for Chemical and Petrochemical, Vol. I, II and III : By E.E. Ludwig, Gulf Publication Co., Houston.

9) Chemical Process Control : An Introduction to Theory and Practice : By Stephanopoulos G., Prentice Hall of India, New Delhi.

10) Chemical Process Equipment Selection and Design : By Stanley M.Walas, Butterworth-Heinemann Series in Chemical Engineering.

11) Process System Analysis and Control : By D.R. Coughanowr, McGraw Hill, New York.

12) Engineering Optimsiation : Theory and Practice : By Rao S.S., New Age Publishing Co., New Delhi.

13) Optmisation of Chemical Processes : By Edgar T.F., Himmelblau D.M., McGraw Hill Book Co., New York.

14) Control Devices, Vol. I and II : Liptak

15) Analysis, synthesis and design of Chemical Processes : Richard Turton, Richard C. Bailie, Wallace B. Whiting, Josheph A. Shaewitz, Prentice Hall Int. Series in Physical and Chemical Science.

ME52105 : Industrial Tribology

Credits: 03 Teaching Scheme: 3 hrs / Week

Course Objectives:
i. To provide the theoretical and practical knowledge of friction, wear and lubrication process.
ii. To learn about tribological modeling and simulation.
iii. To create an awareness of the importance of tribology in design and selection of machine elements.

Course Outcomes:
i. Students will be able to apply the basic theories of friction, wear and lubrication to predictions about the frictional behavior of commonly encountered sliding interfaces.
ii. Able to interpret the latest research on new topics in tribology
iii. To provide students with the understanding and the tools to solve advanced problems in the multidisciplinary field of tribology.

Unit 1 : Friction and wear (6 Hrs)

Theories of friction, types of wear, metals and non-metals.

Unit 2 : Lubrication of bearings (7 Hrs)

Mechanics of fluid flow, Reynold's equation; application to infinitely long bearings, slider bearing, journal bearings, finite bearings.

Unit 3 : Hydrodynamic and hydrostatic bearings (8 Hrs)

Hydrodynamic squeeze film bearings, hydrostatic bearings.

Unit 4 : Gas lubricated bearings (6 Hrs)

Long slider bearings, finite journal bearings, foil bearings.

Unit 5 : Elasto-hydrodynamic lubrication (6 Hrs)

Principles and applications, Hetrz contact stress theory, Ertel-Grubin equation, different regimes in EHL, EHL point and line contact.

Unit 6 : Rolling element bearings (7 Hrs)

Ball bearings, roller bearings, load capacity, lubrication.

Total Contact Hours: 40

Text Books:

1. Introduction to Tribology of bearings: B.C Majumdar, S. Chand and company ltd. New Delhi (2008)
2. Engineering Tribology: Prasanta Sahoo, Prentice Hall of India, New Delhi (2005)

Reference Books :

1. Basic Lubrication Theory: A. Cameron.
   The principles of lubrication: A. Cameron. Longmans Green & Co. Ltd.
2. Theory of Lubrication: B. C. Majumdar, M. Sarangi, M. K. Ghosh, Tata McGraw Hill Education, (2013).
3. Fundamentals of Friction and wear of Materials: American Society of Metals.
4. The Design of Aerostatic Bearings: J.W. Powell.
5. Gas Bearings: Grassam and Powell.
6. Theory of Hydrodynamic Lubrication: Pinkush and Sterrolicht.
7. Engineering Tribology: G. W Stachowiak, , A. W. Batchelor, Boston: Butterworth-Heinemann, 2001.

ME50301: Design Engineering Lab - I

Credits: 04 **Teaching Scheme: 4 hrs / Week**

Course Objectives:- Better understanding of the theoretical concepts covered in theory.

Course Outcomes:- 1. Students will be able to identify and analyze practical problems.
2. Students will be able to model the given problem and use experimentation tools required for the same.

**List of experiments:-

1. **Advanced Stress Analysis**

   i. Plate bending analysis using FEA
   ii. Contact Stress analysis of mechanical components
   iii. Determination of shear center for thin walled cellular structure and its FEA

2. **Vibration and Noise control**

   i. Experiment of multi degree freedom problem. (Whirling of shafts)
   ii. Modal analysis of any mechanical component on FEA software.
   iii. Vibration measurement using FFT analyzer.

3. **Reliability Engineering**

   i. Computation of statistical parameters of the given data using MATLAB (binomial, normal, poisson , weibull and exponential distribution)
   ii. Performing FMEA of any manufacturing process carried out in the workshop
   iii. Performing Failure Rate, Hazard Rate, Mean Time To Failure, MTBF, maintainability, availability Redundancy, Maintainability, Availability analysis of the machines used in workshop.

4. **Advanced Manufacturing Methods**

   i. Study and demonstration of rapid prototyping machine.
   ii. Simulation of wire drawing process on FEA software.
   iii. Simulation of manufacturing process on CAE software.

5. **Thermofluids-I**
   i. Boundary layer over a flat plate simulation
   ii. Simulation on drag of various bodies
   iii. Condensation over a vertical plate

6. **Analysis and Synthesis of Mechanisms**
   i. Kinematic analysis of complex mechanisms.
   ii. Dynamic Analysis of planar mechanisms
   iii. Graphical and Analytical Synthesis.
   iv. Curvature analysis

7. **Process equipment design**
   i. Autocad assignment on process flow diagram
   ii. Visit report for any process industry like sugar factory.
   iii. Pipe stress analysis using Caesar software

8. **Industrial Tribology**
   i. Simulation of finite journal bearing (Hydrodynamic lubrication) with programming software.
   ii. Simulation of Elasto-hydrodynamic lubrication (point and line contact) with a programming software.
   iii. Experiment on hydrodynamic lubrication for journal bearings.

9. **Mathematical methods in Mechanical Engineering**
   i. Simulation heat transfer problem using Rayleigh-Ritz method.
   II. Simulation of stress strain problem using Galerkin method.
   iii. Spline interpolation with Matlab or C code.

**** At least any two experiments can be conducted on each offered course.**

ME56301: Communication and soft skill

Credits: 02 **Teaching Scheme: 2 hrs / Week**

This course will be conducted centrally by BOS-DESH

ME50401 : Comprehensive Viva Voce-I (CVV- I)

Credits: 02 Teaching Scheme: -

Course Objectives:

1. TO ensure that the student has thorough conceptual understanding of Engineering subjects in breadth

2. To ensure that the depth of understanding of applying mathematical subjects extends to more than one subject or / and to more than one discipline.

3. To check that the student has abilities to communicate technical concepts and ideas clearly and that he /she will be able to interpret and express his/her perceptions to an elite audience confidently.

Course Outcomes:

1. The objectives mentioned broadly above will be verified as an outcome

2. The student will be able to define problems of applied interest neatly and also coherently propose methodologies to solve them in known form or in a form demanding research investigation.

3. The student will be of extensive use to an industry

SCOPE

The scope of the VIVA VOCE will include all material which the student is deemed to have assimiliated during the course.

ME57702 : Semester Project- I

Credits: 02 Teaching Scheme: 6 hrs / Week

Course Objectives:

1. To ensure that the student has thorough conceptual understanding of theory subjects.

Course Outcomes:

1. The students will be able to apply theoretical concepts taught in the class on a mechanical system.

Mini project should include either of the following:

1. Student should model and perform simulation of design or heat transfer problem.
2. Student should analyze a system in depth, and draw sound conclusions based on the analysis.
3. Student should model the system and conduct experiments to draw conclusions from the study.
4. Students should perform structural or thermal FE analysis of a mechanical component and discuss the results.

Semester – II

STRUCTURE – SEMESTER II

Subject Code	Subject Name	Type	Teaching scheme (Hrs./week)		Assessment scheme					Credits
					ISA#				ESA	
			Lect.	Practical	CT*	MSE	HA	CA	ESE	
Semester –II										
ME50104	Project Economics and Management	Theory	3	-	10	30	10	-	50	3
ME50105	Advanced Machine Design	Theory	3	-	10	30	10	-	50	3
ME50106	Computer Aided Engineering	Theory	3	-	10	30	10	-	50	3
Elective III		Theory	3	-	10	30	10	-	50	3
ME50109	Advanced Measurement and Data Analysis									
ME52106	Mechanics of Composite Materials									
ME52107	Optimization Technique									
Elective IV		Theory	3	-	10	30	10	-	50	3
ME52108	Vehicle Dynamics									
ME52109	Robotics									
ME50111	Design of Heat Exchangers									
ME50302	Design Engg. Lab-II	Lab	-	4	-	-	-	100	-	4
ME57701	Technical Seminar-I	Lab	-	2	-	-	-	100	-	4
ME50402	CVV-II	Lab	-	-	-	-	-	-	100	2
ME57703	Semester Project-II	Oral	-	6	-	-	-	-	100	2
Total			**15**	**12**						**27**

***** CT (Unit 1) 1 hour 30 marks converted to 10 marks + HA (minimum 3) – Total 30 marks converted to 10 marks = 20 marks

MSE – 2 hours 60 marks converted to 30 marks (Unit 2 & 3), ESE – 3 hours 100 marks converted to 50 marks (Unit 1 to 6)

\# ISA – In Semester Assessment, ESA – End Semester Assessment, CT- Class Test,

MSE – Mid Semester Examination, HA- Home Assignment, CA – Continuous Assessment, ESE – End Semester Examination

ME50104: Project Economics and Management

Credits: 03 **Teaching Scheme: 3 hrs / Week**

Course Objectives:

1. To provide an introduction to project management and the tools required to monitor administrate and control projects
2. To enable Students to appreciate engineering economics and costing.
3. To provide students with the fundamentals of management.

Course Outcomes:

1. To inculcate in students the interdisciplinary usage of Project management
2. To apply IT tools Microsoft Project for implementation of the knowledge attained in the course
3. To understand fundamental concepts of Management and creative problem solving
4. To be able to appreciate methods used in Industry leading to economic use of resources
5. For reducing cost and improving the environments
6. To understand sustainability in a Lean environment .

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Unit 1 : Project Management (6 Hrs)

Introduction to Principles of Project Management, Time management, time management tools , planning systems, PERT Charts, Gantt Charts
Networking and Network Problems. CPM.

Unit 2 : (6 Hrs)

Project Management tools : . Use of at least one tool - viz.

Microsoft Project / HTPM (Harvard Total Project Manager)/ Primavera
Use of tools to make Gantt Charts, PERT charts and allocation of resources etc, Project Crashing Project Finance.

Unit 3 : Costing (8 Hrs)

Costing and Cost accounting fundamentals, Types of costs, Market potential assessment for costing products goods and services. Breaking Even Costs, Breakeven problems . Psychology: How to be Lucky, Communications Johari Window Case study of costing/ Market assessment.

Unit 4 : General Management (6 Hrs)

Need of Managers Planning , Organizing , Directing, Staffing , Controlling. Operations management, Management classifications , Mathematical modeling of Management thought – 2D , Organizational Behavior , Decision making.

Unit 5 : Management (7 Hrs)

Problems solving ,Negotiations, Power games When to choose to fight, Conflict management, Motivation and Motivational management. Operations Management – Inventory Control

Quality Systems , ISO 9001, 6 Sigma, 5 S , Kaizen. DemingsPhilosophy , World Class manufacturing.

Marketing Management . Strategy formulation exercise – 2D . Marketing vs Sales. Sell Strategy determination tools. Startup Business Model canvas and Alexander Osterwalders 9 model theory. Advertising and Brand management

Unit 6 : Management : Human Relations (7 Hrs)

Fundamentals of Human Relations Management, Purpose of HRM , Social Skills, Successful managers , Recruitment, Retention and Termination management. 7 Habits Paradigm, Table and Telephone etiquette, Team building self and team development. Performance appraisals , Counselling and BOSS management.

Total Contact Hours: 40

Text Books:

1. Project Management by Nagarajan
2. Statistics by Gupta
3. Principles and Practice of Management - By Koontz and O' Donell
4. Marketing Management by Kotler
5. Class notes and handouts

Reference Books :

1. Seven habits by Stephen Covey
2. Management by Objectives - Peter Drucker
3. 365 meditations for teachers by Greg Henry Quinn
4. All students are advised to Harvard business school press publications on the web or at the library to read further

Title: Syllabus Format – PG Courses **FF No. : 658**

ME50105 : Advanced Machine Design

Credits: 03 **Teaching Scheme: 3 hrs / Week**

Objectives

i. To study design concepts in order to enhance the basic design.
ii. To study behaviour of mechanical components under fatigue and creep.
iii. To study statistical techniques and its applications in mechanical design.

Outcomes :

i. Students will have the ability to analyze mechanical elements critically.
ii. Students will have the ability to analyze behaviour of mechanical elements under fatigue and creep.
iii. Students will understand applications of statistical techniques in mechanical design.

UNIT 1 : CAMS (6 hrs.)

Advanced curves: 2-3 polynomial, 3-4-5 polynomial, 4-5-6-7 polynomial & higher order polynomial.

Polydyne cams: 3-4-5 cam, cycloidal cam. Pressure angle, radius of curvature, force on follower and cam, cam design with elasticity of part is considered, ramps.

UNIT 2 : GEARS (6 hrs.)

Dynamic load, constants of the dynamic system, contact stresses in gears, profile modification, extended centre distance system of gearing, long and short addendum gearing, backlash, undercutting .

UNIT 3 : SPRINGS (8 hrs.)

Helical springs under static and fatigue or variable loading, buckling of helical compression spring, vibration and surging of helical springs, Optimum design of helical spring.

Design analysis of Belleville springs, ring spring, volute spring, rubber springs and mountings.

UNIT 4 : DESIGN AGAINST FATIGUE (8 hrs.)

Fatigue Damage theories, Cycle counting Techniques, Stress based fatigue Analysis & design: one dimensional analysis, multiaxial analysis, Cumulative damage. Strain based

fatigue Analysis & design: one dimensional analysis, multiaxial analysis .Surface integrity & fatigue life improvement.

UNIT 5 : DESIGN AGAINST CREEP (6 hrs.)

True stress and true strain, creep of material at high temperature, creep parameters, exponential creep law, hyperbolic sine creep law, etc. Estimated time to rupture, correlation of creep-rupture data, stress relaxation, creep in bending, etc. materials for application at elevated temperatures.

UNIT 6: ENGINEERING STATISTICS (6 hrs.)

Analysis of variance (ANOVA), factorial design and regression analysis, Reliability theory, design for reliability, Hazard analysis, fault tree analysis.

Total Contact Hours: 40

Text Books :

1) Mechanical Design Analysis – M.F. Spotts , Prentice Hall
2) Mechanical Springs – A.M. Wahl, first edition; Cleveland: Penton Pub. Co.

REFERENCE BOOKS

1) CAMS: design, dynamics, and accuracy – H.A. Rothbart, Wiley
2) Fatigue Design: life expectancy of machine parts –Eliahu Zahavi & Valdimir Torbilo, CRC Press
3) Machine Design – Robert Norton, Prentice Hall
4) Handbook of Practical Gear Design – D W Dudley, McGraw-Hill Companies
5) Cam design handbook H.A. Rothbart, McGraw-Hill, 2004

ME50106 : Computer Aided Engineering

Credits: 03 **Teaching Scheme: 3 hrs / Week**

Course Objectives:

i. Understand the fundamental ideas of the solid modeling.
ii. Understand the fundamental ideas of the FEM.
iii. Understand the fundamental ideas of the Computational Fluid Dynamics
iv. Can interpret and evaluate the quality of the results.
v. Learn how the finite element method is implemented (both algorithmically and numerically) by developing simple finite element computer code
vi. Develop finite element formulations of engineering problems from a variety of application areas including stress, heat transfer, and vibration analysis.
vii. Be aware of the limitations of the FEM. Learn to use Nastran® /ANSYS (Commercial finite element programs)

Course Outcomes:

1. Knowledge of the governing equations for commonly encountered mechanical engineering problems.
2. Students will learn the mathematical formulation of the finite element method and how to apply it to basic (linear) ordinary and partial differential equations
3. Modeling and simulation of complex engineering problems by proper selection of finite element and boundary conditions.
4. Ability to solve linear, nonlinear and dynamic analysis problems using 1D, 2D and 3D FE models.
5. Ability to think laterally and originally, conceptualise and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering all necessary factors.
6. Usage of commercial FE softwares to solve complex engineering problems with an understanding of their limitations.
7. Using Nastran®/ANSYS perform stress, thermal, and modal analysis

Unit 1: Solid Modeling **(7 hrs.)**

Geometry & Topology, Solid representation, Techniques of volume modeling, Feature based modeling: Feature representation, Parametrics, Relations, Constraints, Feature Manipulation. Mass properties calculations, Assembly modeling and Assembly analysis. Product Data Exchange.

Unit 2: One dimensional Finite Element Analysis (7 hrs.)

Linear bar element, Quadratic bar element, beam element, frame element. Development of Finite Element Models of discrete systems like Linear elastic spring, Torsion of Circular Shaft, Fluid flow through pipe, One dimensional conduction with convection.

Unit 3: Two dimensional Finite Element Analysis (7 hrs.)

Three noded triangular element, six noded triangular element, four noded quadrilateral element, eight noded quadrilateral element and nine noded quadrilateral element. Development of Finite Element Models for plane stress, plane strain, Axisymmetric stress analysis applications.

Unit 4: Dynamic Analysis Using Finite Elements (7 hrs.)

Vibration problems, Equations of motion based on weak form, Equations of motion using Lagrange's approach, consistent and lumped mass matrices, Solution of Eigenvalue problems, Transient vibration analysis.

Unit 5: Computational Flow Simulation (5 hrs.)

Meshing for flow simulation, finite volume methods, pressure-velocity coupling, numerical stability.

Unit 6: Three dimensional Finite Element Analysis (7 hrs.)

Four node tetrahedral element, six node prism element, Eight node Hexahedral element and higher order elements. Boundary conditions, Mesh Generation, Mesh Refinement and other practical considerations.

Total Contact Hours: 40

Text Books:

1. Ibrahim Zeid, 'Mastering CAD/CAM', Tata McGraw Hill Co. Ltd. 2007
2. Larry J. Segerlind, 'Applied Finite Element Analysis', John Wiley & Sons, New York, 1984.
3. T Sundararajan and K Muralidhar, 'Computational Fluid Flow and Heat Transfer', Alpha Science International, Ltd., 2003.
4. T R Chandraupatla, A D Belegundu, 'Introduction to Finite Elements in Engineering', Pearson Education, 3rd Ed. 2004.

Reference Books:

1. D F Roger, J Adams, 'Mathematical Elements for Computer Graphics', McGraw Hill Co. Ltd. New York, 1990.
2. J N Reddy, 'Introduction to Finite Element Method' , Tata McGraw Hill Co. Ltd, 2005
3. K H Huebner, D L Dewhirst, D E Smith, T G Byrom, 'The Finite Element Method for Engineers', John Wiley & Sons, New York, 2008.
4. P. Sheshu, Textbook of Finite Element Analysis, Prentice Hall of India, 2004.

ME50109 : Advanced Measurement and Data Analysis

Credits: 03 **Teaching Scheme: 3 hrs / Week**

Course Objectives:

To learn principles of data analysis and advanced techniques used for measuring field and derived quantities in mechanical engineering

Course Outcomes:

i. Students will learn how to measure field parameters like temperature, heat flux measurement, measurement of force, pressure, flow rate, velocity, humidity, noise, vibration and derived parameters like torque, power, thermo physical properties, radiation and surface properties.

ii. They will learn to do regression analysis of the data and find useful correlations.

Unit 1: Introduction to advanced measurement methods (6 Hrs)

Introduction to measurements for scientific and engineering application, Broad classification of methods for measuring field and derived quantities

Unit 2: Data analysis (6 Hrs)

Principles of measurement, parameter estimation, regression analysis, correlations, error estimation and data presentation, analysis of data

Unit 3: Field quantities measurement (8 Hrs)

Measurement of field quantities: thermometry, heat flux measurement, measurement of force, pressure, flow rate, velocity, humidity, noise, vibration

Unit 4: Derived quantities measurement (8 Hrs)

Measurement of derived quantities: torque, power, thermo physical properties, radiation and surface properties

Unit 5: Analytical methods (6 Hrs)

Analytical methods and pollution monitoring, mass spectrometry, chromatography, spectroscopy

Unit 6: Types of control actions (6 Hrs)

Basics of P, PI, PID controllers, pneumatic and hydraulic controllers, electronic controllers, applications to machine tools, furnaces, material handling etc

Total Contact Hours: 38

Text Books:

1. Doebelin E.O., Measurement Systems-Application and Design, Mc-Graw Hill Publication Co.
2. Bolton W., Mechatronics-Electronics Control Systems in Mechanical and Electrical Engg., Pearson
3. Beckwith TG. N. Lewis Buck and Marangoni R.D, Mechanical Measurements, Narosa Publishing House, New Delhi

Reference Books:

1. Liptak B.G. Instrument Engineers' Handbook
2. Johnson C.D., Process Control Instrumentation, Pearson
3. J. P. Holman: Experimental Methods For Engineers, Mc-Graw Hill International

Title: Syllabus Format – PG Courses **FF No. : 658**

ME52106 : Mechanics of Composite Materials

Credits: 03 **Teaching Scheme: 3 hrs / Week**

Objectives

i. To provide students with a perspective on utilization of composite materials in machines and structure
ii. To teach students to analyze composite materials using anisotropic continuum theory.
iii. To provide students with a design experience involving composite materials

Outcomes

i. Students will understand merits and demerits of composite materials as competing material to traditional materials.
ii. Students will be able to analyze and interpret stiffness and strength properties of composite laminates.
iii. Students will understand mechanical properties determined from experiments and their utilization in composite analysis.
iv. Students will be able to design an elementary level representative machine components or structures made of composite materials

Unit 1: **(06)**

Introduction to Composite Materials, Advantages & Applications, basic concepts, Constituent Materials, Manufacturing Methods, Methods of non-destructive evaluation of polymer composites.

Unit 2 : **(07)**

Elastic behaviour of composite lamina-Micromechanics: Micromechanics methods, Geometric aspects and elastic symmetry, longitudinal and transverse properties, inplane shear modulus, longitudinal properties of discontinuous fibers

Unit 3 : **(07)**

Elastic behaviour of composite lamina-Macromechanics: Stress-Strain relations, relation between mathematical and engineering constant, transformation of stress & strain, elastic parameters, Stress-Strain relations in terms of engineering constants.

Unit 4 : **(07)**

Strength of unidirectional lamina-Micromechanics: Longitudinal tension & compression, transverse tension & compression, inplane Shear and out of plane loading.
Strength of unidirectional lamina-Macromechanics: Failure theories – Maximum stress theory, Maximum strain theory, Energy based theory, evaluation and applicability of lamina failure theories.

Unit 5 : **(07)**

Elastic behaviour of multidirectional laminates: Strain displacement relations, Stress-Strain relations of layer within laminate, load – deformation relations, symmetric laminates, orthotropic laminates, quasi-isotropic laminates.

Unit 6 : **(06)**

Experimental methods for characterization and testing of composite materials : Characterization of constituent Materials, Physical Characterization of composite materials, Determining Tensile, compressive , shear properties of Unidirectional lamina, Determination of through thickness properties, Interlaminar Fracture Toughness , Biaxial testing, Characterization of composite with Stress concentration.

Total Contact Hours: 40

Text Books :

1. Engineering Mechanics of Composite Materials - Issac M Daniel & Ori Ishai , Oxford University Press Inc., New York 10016

2. Mechanics of Composite Materials and Structures - M. Mukhopadhyay, Universities Press

Reference Books

1. Mechanics of Composite Materials - Autar K Kaw, CRC Press ,Taylor & Francis Group
2. Composite Materials – Design and Applications by Daniel Gay, Suong V. Hoa, Stephen W. Tsai , CRC press, Taylor & Francis Group
3. An Introduction to Composite Materials - Hull, D. and Clyne, T.W., Cambridge University Press
4. Mechanics of Composite Materials - R. M. Jones, Taylor & Francis, Inc.
5. Theory and Analysis of Elastic Plates and Shells - Reddy, J. N., CRC Press

ME52107 : Optimization Techniques

Credits: 03 Teaching Scheme: 3 hrs / Week

Course Objectives: To make the students o learn different methods of optimization to solve engineering problems**.**

Course Outcomes:

i. Develop the ability to obtain the optimal solution for engineering problems
ii. Are in a position to model engineering problems and pose it as an optimisation problem
iii. Apply the optimisation methods to design a thermal/flow system

Unit 1 : (7Hrs)

Review of Maths, calculus, linear algebra, function of several variables, extrema, constrained extrema

Unit 2 : (7 Hrs)

One-dimensional optimization: polynomial(quadratic, cubic) methods, golden search method, iterative methods

Unit 3 : (7 Hrs)

Gradient based methods: conjugate gradient, steepest descent, examples

Unit 4 : (7 Hrs)

Linear programming: simplex, dual simplex, case studies

Unit 5 : (7Hrs)

Constrained optimisation: Lagrange multipliers, transformation, linearisation methods

Unit 6 : (5 Hrs)

Evolutionary algorithms: Box complex methods, genetic algorithm, case studies

Total Contact Hours: (40)

Text Books:

1. Engineering Optimization, Singiresu S. Rao, New Age International(P) Ltd., Bombay

Reference Books :

1. Optimization: Theory and Practice, Mohan Joshi and KannanMoudgalya, Narosa Publishing House, Bombay.
2. Optimization: concepts and application engineering, Ashok Belegundu and TirupathiChandrupatla, Pearson Education Asia, Delhi.

Title : Syllabus Format – PG Courses

ME52108: Vehicle Dynamics

Credits: 03 **Teaching Scheme: 3 hrs / Week**

Course Objectives:

1. To give the student knowledge about modelling and analysis of vehicle's dynamic behaviour.
2. To explain concepts in vehicle control relating to traction/braking, handling/steering, and suspension.
3. To create a vehicle model and analyse the same.

Course Outcomes:

1. The students will be able to describe the basic terms in vehicle dynamics.
2. The students will able to create and analyse simple models of vehicles for dynamic analysis.
3. The students will be able to understand effects of different vehicle parameters on its performance.

Unit 1 : Mechanics of Pneumatic tires (4 Hrs)

Tire construction, Tire forces and Moments ,rolling resistance , tractive efforts , cornering properties ride properties

Unit 2 : Performance characteristics of road vehicles (7 Hrs)

Equations of motion , aerodynamic forces / moments , transmission characteristics , vehicle performance , braking performance

Unit 3 : Handling characteristics (10 Hrs)

Steering geometry , steady state handling , testing of handling characteristics , directional stability

Unit 4 : Vehicle ride characteristics (7 Hrs)

Human response , vehicle ride models , vehicle response

Unit 5 : Suspensions (7 Hrs)

Axles , independent suspensions , suspension geometry , roll centre analysis , rubber and air suspensions

Unit 6 : Steering system (5 Hrs)

Steering geometry , steering forces and moments , steering system models

Total Contact Hours: 40 Hrs.

Text Books:

1. Gillespie T, D. ,Fundamentals of Vehicle Dynamics , Society of Automotive Engineers
2. Giles J. G., Steering , Suspension and tyres , ILIFFE Books Ltd.
3. Ellis J. R., Vehicle handling dynamics, Mechanical Engineering Publications Ltd. London

Reference Books :

1. Dixon J. C. , Tyres, Suspension and handling ,Cambridge university press.
2. Wong J.Y., Theory of Ground vehicles, John Wiley & Sons.

ME52109: Robotics

Credits: 03 **Teaching Scheme: 3 hrs / Week**

Course Objectives: This course provides an in-depth coverage of the central topics in robotics, namely geometry, kinematics, differential kinematics, dynamics, and control of robot manipulators.

Course Outcomes: At the end of the course, students will

i. understand the basic concepts of robotics including kinematics, dynamics, actuators, controllers, etc;
ii. Implement robot control algorithms, both open loop and closed loop
iii. Understand the different sensors used in robotics
iv. Understand the End Effectors used in robotics

Unit-I

Robot Fundamentals:-

Definitions, History of robots, present and future trends in robotics, Robot classifications, Robot configurations, Point to Point robots, Continuous Path robots, Work volume, Issues in design and controlling robots Repeatability, Control resolution, spatial resolution, Precision, accuracy, Robot configurations, Point to Point robots, Continuous Path robots, Work volume, Applications of robots. [7 hrs]

Unit-II

Manipulator Kinematics:-

Matrix Algebra, Inverse of matrices, rotational groups, matrix representations of coordinate transformation, transformation about reference frame and moving frame Forward & Inverse Kinematics examples of 2R, 3R & 3P manipulators, Specifying position and orientation of rigid bodies Euler's angle and fixed rotation for specifying position and orientation Homogeneous coordinate transformation and examples D-H representation of kinematics linkages Forward kinematics of 6R manipulators using D-H representations Inverse kinematics of 6R manipulators using D-H representations, Inverse Kinematics geometric and algebraic methods.

[7hrs]

Unit-III

Robotics Dynamics:-

Velocity Kinematics, Acceleration of rigid body, mass distribution Newton's equation, Euler's equation, Iterative Newton –Euler's dynamic formulation, closed dynamic,

Lagrangian formulation of manipulator dynamics, dynamic simulation, computational consideration.

Robot Controllers:-

Essential components-Drive for Hydraulic and Pneumatic actuators, Independent joint control, PD and PID feedback, actuator models, nonlinearity of manipulator models, issues in nonlinear control, force feedback, hybrid control [7hrs]

Unit-IV

Trajectory planning:-

Introduction, general considerations in path description and generation, joint space

schemes, Cartesian space schemes, path generation in runtime, planning path using dynamic model point to point and continuous trajectory , 4-3-4 & trapezioidal velocity strategy for robots. [5hrs]

Unit -V

END EFFECTORS: Grippers-types, operation, mechanism, force analysis, tools as end effectors consideration in gripper selection and design.

Robot Sensors:-

Internal and external sensors, position- potentiometric, optical sensors ,encoders - absolute, incremental ,touch and slip sensors velocity and acceleration sensors, proximity sensors, force & torque sensors,.

Robot Vision:-

Camera model and perspective transformation, image processing fundamentals for robotic applications, image acquisition and pre-processing.. [7hrs]

Unit VI

ROBOT APPLICATIONS: Material transfer, Machine loading/unloading. Processing operation, Assembly and Inspection, Feature Application.

Robot Programming languages:-

Introduction the three level of robot programming, requirements of a robot programming

language, problems peculiar to robot programming. Robot programming as a path in space, Motion interpolation, WAIT, SINGNAL AND DELAY commands, Branching capabilities and Limitations.

Futuristic topics in Robotics:-

Micro-robotics and MEMS (Microelectrode mechanical systems), fabrication technology for Micro-robotics, stability issue in legged robots, under-actuated manipulators.

[7hrs]

Total Contact Hours: 40

TEXT BOOKS:

1. Industrial robotics Mikell P.Groover McGraw Hill.
2. Robotics / K.S.Fu / McGraw Hill
3. J.J.Craig , introduction to Robotics , Addision-wesely 1989

Reference Books:

1) S.R.Deb, " Robotics Technology and Flexible Automation ", Tata Mc Graw Hill 1994.
2) M.P.Groover, M. Weiss R.N. Nagel, N.G. Odrey " Industrial Robotics (Technology , Programming and application s) , McGraw, Hill 1996
3) J.J.Craig , introduction to Robotics , Addision-wesely 1989.
4) Klafter , Richard D., et al " Robotics Engineering",PhI,1996.
5) Zuech,Nello,"Applying Machine Vision ",john Wiley and sons, 1988
6) R.K.Mittal and I J Nagarth .,Robotics and control , Tata McGrawhill,2004

ME50111: Design of Heat Exchangers

Credits: 03 Teaching Scheme: 3 hrs / Week

Course Objectives:

- **i** Know common heat exchanger types, their advantages and limitations
- **ii** Learn how to handle rating and sizing problems in heat exchanger design
- **iii** Understand how to consider fouling of surfaces, incorporate fouling in designs, and handle fouling during heat exchanger operation

Course Outcomes:

- **i** Learn how to design common types of heat exchangers; namely shell-and-tube, gasketed plate. Learn to select appropriate Heat Exchanger for the given application.
- **ii** Will understand uses in some new engineering areas or in innovative applications
- **iii** Become aware of and will appreciate single and multiphase heat transfer and friction coefficient correlations, and they will know how to select the appropriate ones for the case in hand

Unit 1 : Introduction **(5 hrs)**

Heat Exchangers: Meaning, Classification, Significance, Applications and Selection

Unit 2 : Basic Design Process **(8 hrs)**

Thermal Design: Thermal-Hydraulic fundamentals, Performance evaluation of Heat Exchangers. LMTD, e-NTU methods, Fouling. Rating and sizing problems, Heat Transfer and Pressure drop calculations. Standards (TEMA).

Mechanical Design: Design standards and codes, key terms in heat exchanger design, material selection, and thickness calculation for major components such as tube sheet, shell, tubes, flanges etc. Flow induced vibrations.

Unit 3 : Design of Shell and Tube Heat Exchanger **(9 hrs)**

Thermal Design of Shell and Tube heat exchanger: Tinker's, Kern's and Bell Delaware's method. Introduction to automotive heat exchanger; Compact heat exchangers.

(8 hrs)

Unit 4 : Design of Plate Heat Exchanger

Thermal Design of plate Heat Exchangers; condensers, boilers, Super heaters, cooling towers etc.

Unit 5 : Heat Transfer Enhancement and Performance Evaluation (6 hrs)

Enhancement of heat transfer, Performance evaluation of Heat Transfer Enhancement technique. Introduction to pinch analysis.

Unit 6 : Introduction to Simulation and Optimization (6 hrs)

Modeling and commercial codes. Introduction to simulation and optimization of heat exchangers.

Total Contact Hours: 42

Text Books:

1. Sadik Kakac, and Hongtan Liu, "Heat Exchangers: Selection, Rating and Thermal Design", 2nd edition, CRC Press, 2002
2. R. K. Shah, D. P. Sekulic, "Fundamentals of Heat Exchanger Design", John Wiley and Sons, Inc., 2003.
3. D.C. Kern, "Process Heat Transfer", McGraw Hill, 1950.
4. Frank P. Incropera and David P. De Witt, "Fundamentals of Heat Transfer", Wiley, Eastern Limited.

Reference Books:

1. T. Kuppan, "Hand Book of Heat Exchanger Design".
2. "T.E.M.A. Standard", New York, 1999.
3. Kays and London, "Compact Heat Exchanger".
4. G. Walker, "Industrial Heat Exchangers-A Basic Guide", McGraw Hill, 1982.

ME50302: Design Engineering Lab- II

Credits: 04 **Teaching Scheme: 4 hrs / Week**

Course Objectives:- Better understanding of the theoretical concepts covered in theory.

Course Outcomes:-
1. Students will be able to identify and analyze practical problems.
2. Students will be able to model the given problem and use experimentation tools required for the same.

**List of experiments:-

1. **Project Economics and Management**
   i. Task allotment with MS project
   ii. Resources utilization with MS project
   iii. Multiple tasking and parallel projects

2. **Advanced Machine Design**

   i. Dynamic analysis of Cam Follower Mechanism
   ii. Contact Stress analysis of Gear and its FEA
   iii. Parametric study and analysis of springs like Belleville spring/Ring spring/volute spring etc.

3. **Computer Aided Engineering**

   i.Finite Element Analysis of 2D , 3D problems using commercial FEA Software
      1. Gear tooth analysis
      2. Crane Hook analysis
      3. Plate with hole & study of stress concentration
      4. Pressure Vessel stress Analysis
      5. Connecting Rod, Crank Shaft, Cam Shaft stress Analysis.
   ii. Flow Simulation: Flow through pipes, flow over bodies.
   iii. Computer Implementation of 2-D Problems.

4. **Advanced Measurement and Data Analysis**
   i. Calibration of pressure gauge
   ii. Calibration of thermocouple
   iii. Problem on analysis of data and error estimation

5. Mechanics of Composite Materials

i. Analysis of simple mechanical component made of composite material by FEA
ii. Study and analysis of effect of fiber orientation on different properties of composites.
iii. Study and analysis of effect of fiber materials and its volume ratio on different properties of composites.

6. Optimization Technique

i. Optimization of a mechanical component using Matlab
ii. Optimization of a thermal system using Matlab
iii. Optimization of turbo machines

7. Vehicle Dynamics

i. Analysis of vehicle test data for steady state cornering.
ii. Analysis of vehicle test data for transient cornering.
iii. Simulation of vehicle quarter car model for handling characteristics

8. Robotics

i. Simulation of reverse kinematics using Matlab.
ii. Simulation of trajectory planning with Matlab robotics toolbar
iii. Simulation of Forward kinematics using Matlab.

9. Design of Heat Exchangers

i. Trial on shell and tube heat exchanger
ii. Trail on compact heat exchanger
iii. Simulation of shell and tube heat exchanger using commercial software

**** Any two experiments should be conducted from each of the offered subject.**

ME57701 : Technical Seminar - I

Credits: 04 **Teaching Scheme: 2 hrs / Week**

Course Objectives:

i. To empower the student to learn beyond what is taught in class by reviewing literature available at large
ii. A student is expected to review research papers periodicals , magazines and review publications on the internet and in other electronic resources.
iii. Student is expected to present views coherently to produce a presentation concisely with the surveyed information under the direction of the research guide.

Course Outcomes:

Under the influence of the project guide -To engage the student directly or indirectly in research at different levels, from advancing their course materials, professional development, to funded research projects to advance the state of practice.

SCOPE

The scope of the technical seminar will include but not restricted to the discipline of work for the final year thesis The scope will include

Survey of patents,

Research journals books and databases

Field survey and site visit reports

Communication from experts.

ME50402 : Comprehensive Viva Voce-II (CVV – II)

Credits: 02 **Teaching Scheme: -**

Course Objectives:

1. To ensure that the student has thorough conceptual understanding of Engineering subjects in breadth

2. To ensure that the depth of understanding of applying mathematical subjects extends to more than one subject or / and to more than one discipline.

3. To check that the student has abilities to communicate technical concepts and ideas clearly and that he /she will be able to interpret and express his/her perceptions to an elite audience confidently.

Course Outcomes:

1. The objectives mentioned broadly above will be verified as an outcome

2. The student will be able to define problems of applied interest neatly and also coherently propose methodologies to solve them in known form or in a form demanding research investigation.

3. The student will be of extensive use to an industry

SCOPE

The scope of the VIVA VOCE will include all material which the student is deemed to have assimilated during the course.

ME57703 : Semester Project- II

Credits: 02 **Teaching Scheme: 6 hrs / Week**

Course Objectives:

To ensure that the student has thorough conceptual understanding of theory subjects.

Course Outcomes:

The students will be able to apply theoretical concepts taught in the class on a mechanical system.

Mini project should include either of the following:

1. Student should design mechanical gear box, clutch assembly, etc. Design should contain calculation, structural and/or thermal analysis and complete drawing of the system.
2. Student should perform FE analysis of mechanical components taking in to account material nonlinearities and contact elements.
3. Experimentation on engine test rig for advanced measurement and data analysis.
4. Design optimization of mechanical component using Matlab.

Semester – III

STRUCTURE – SEMESTER III

Subject Code	Subject Name	Type	Teaching scheme (Hrs./week)		Assessment scheme					Credits
					ISA				ESA	
			Lect.	Practical	CT*	MSE	HA	CA	ESE	
Semester –III										
HS66101	Institute level Open Elective	Theory	2	-	10	30	10	-	50	2
	Dept. level Open Elective	Theory	2	-	10	30	10	-	50	2
ME66101	Advanced Material Science									
ME66102	Chassis and Body Engineering									
ME66103	Design of Experiments									
ME67702	Dissertation Stage I	Lab	-	4#	-	-	-	-	100	15
ME67701	Technical Seminar II	Lab	-	2	-	-	-	-	100	4
Total			**4**	**6**						**23**

***** CT (Unit 1) 1 hour 30 marks converted to 10 marks + HA (minimum 3) – Total 30 marks converted to 10 marks = 20 marks

MSE – 2 hours 60 marks converted to 30 marks (Unit 2 & 3), ESE – 3 hours 100 marks converted to 50 marks (Unit 1 to 6)

ISA – In Semester Assessment, ESA – End Semester Assessment, CT- Class Test,

MSE – Mid Semester Examination, HA- Home Assignment, CA – Continuous Assessment, ESE – End Semester Examination

- Student is expected to work around 40 hours per week as Self Study

HS66101: Institute Level Open Elective

Credits: 02 **Teaching Scheme: 2 hrs / Week**

This course will be conducted centrally by BOS DESH

Title : Syllabus Format – PG Courses **FF No. : 658**

ME66101: Advanced Material Science

Credits: 02 Teaching Scheme: 2 hrs / Week

Course Objectives: - To cover the aspects of physical metallurgy and study equilibrium diagram for various alloys. To introduce students to latest trend in material science.

Course Outcomes:-

- Students will be able to decide suitable heat treatment for given alloy.
- The students will be familiar with latest trends in material science related to smart material and surface coatings.

Unit 1: (5 Hrs)

Aspects of Physical Metallurgy: Crystal structure, systems and Barvias lattices, Indexing of lattice planes (Miller's Indices), Indexing of lattice directions, Co-ordination Number (Ligency), Density calculations and imperfections in crystals.

Unit 2 : (5 Hrs)

Study of Equilibrium diagrams for Fe-C systems, Cu - Bronze alloys i.e. Cu:Zn, Cu:Sn, Cu:Al etc., Developments in metallic materials like HSLA state, maraging steels, dual phased steels, creep resisting steels, materials for high and low temperature applications, Nimerics, Inconels, Haste Alloys etc., Al, Ni alloys, Ti, Mg alloys.

Unit 3 : (4 Hrs)

Heat Treatment of Non ferrous alloys, Heat Treatment of Tool steels

Unit 4 : (5 Hrs)

Orthodental materials, Bio material, Prosthetic materials, Nano materials, super conducting materials, sports materials.

Unit 5 : (4 Hrs)

Composites, ceramics, cermets, shape memory alloys their manufacturing techniques,

advantages and limitations.

Unit 6 : **(5 Hrs)**

Surface coatings and their tribological aspects. PVD, CVD, IVD ion implantation method.

Total Contact Hours: 28

Text books:

1. Material Science and Engineering an Introduction, William D. Callister, Jr., John Wiley and Sons Inc.
2. Smithells Metals Reference Book, E. A. Brandes and G. B. Brook, Butterworth Heinemann.
3. Biomaterials and Bioengineering Handbook, Donald L. Wise, Marcel Dekker Inc.

Reference Books :

1. Engineering Metallurgy, R. A. Higgins, Viva Books Pvt. Ltd.
2. Elements of Material Science and Engineering, Lawrence H., Van Vlack Addison-
   Wesley Publishing Company
3. Principles of Material Science and Engineering, William F. Smith, McGraw-Hill Book Co.
4. Material Science, R. B. Gupta, Satya Publications, New Delhi.
5. A Text Book of Material Science and Metallurgy, O. P. Khanna, Dhanpat Rai and Sons, New Delhi.

Title : Syllabus Format – PG Courses **FF No. : 658**

Department level open elective

ME 66102: Chassis & Body Engineering

Credits: 02 **Teaching Scheme: 2 hrs / Week**

Course Objectives:

- To help students to understand constructional details of car body and chassis design.

- To help students to understand safety concepts in car body and chassis design.

Course Outcomes:

- Students will be able to design car body and chassis for given vehicle details.

Unit 1 **(6 Hrs)**

Car Body Details : Types of car bodies, visibility, regulations, driver's visibility, methods of improving visibility, safety design.

Unit 2 **(4 Hrs)**

Car Body Details : constructional details of roof, under floor, bonnet, boot, wings etc, Classification of coach work.

Unit 3 **(4 Hrs)**

Design of Vehicle Bodies: Vehicle body materials, Layout of the design, preliminary design, safety, Idealized structure- structural surface, shear panel method, symmetric and asymmetrical vertical loads in car, longitudinal loads, different loading situations- load distribution on vehicle structure.

Unit 4 **(4 Hrs)**

Design of Vehicle Bodies : Calculation of loading cases, stress analysis of bus body structure under bending and torsion, stress analysis in integral bus body, Design of chassis frame, Rules and regulations for body.

Unit 5 **(5 Hrs)**

Design of Vehicle Bodies : Recent safety measures, Testing of body.

Unit 6 **(5 Hrs)**

Design of Chassis Frame: layout, components, performance requirement, Strength of material techniques, Materials,

Total Contact Hours: 28

Text books:

1. Commercial vehicle Structures – By Beerman
2. Vehicle Body Engineering – Pawloski J., Business Books Ltd.

Reference Books:

1. The Automotive Chassis: Engineering Principles – Reimpell J.
2 Vehicle Body Layout and Analysis – John Fenton, Mechanical Engg. Publications Ltd.London
3. Body Construction and Design – Giles J. G., Illife Books, Butterworth and Co.

Department level open elective

ME66103: Design of Experiments

Credits: 02 Teaching Scheme: 2 hrs / Week

Course Objectives: To cover the statistical design of experiments for systematically examining functioning of the system.

Course Outcomes:

Design/apply fractional factorial experiments for simple experimental case studies and analyze data collected for such experiments.

Unit 1: (4 Hrs)

Introduction to DoE, Research Design Principles.

Unit 2 : (6 Hrs)

Completely Randomized Designs, Treatment Comparisons, Diagnostics and Remedial Measures.

Unit 3 : (4 Hrs)

Experiments to Study Variances.

Unit 4 : (5 Hrs)

Factorial Designs: Random and Mixed Models

Unit 5 : (5 Hrs)

Complete Block Designs, Analysis of Covariance{Including a Measured Covariate}

Unit 6 : **(4 Hrs)**

Two case studies on application of DoE to any process or mechanical industry.

Total Contact Hours: 28

Text books:

1. Box, GEP, Hunter, WG, and Hunter, JS, 1978, Statistics for Experimenters, Wiley.
2. Box, GEP and Draper, NR 1987, Empirical Model-Building and Response Surfaces, Wiley.

Reference Books :

1. Cochran, WG and Cox, GM, 1957, Experimental Designs, Wiley.
2. Fisher, RA, 1966, The Design of Experiments, 8th edit., Hafner.

ME67702: Dissertation Stage I

Credits: 15 Teaching Scheme: 4 hrs/week (Practical)

Course Objectives:

1. To help the students to apply theoretical knowledge to any practical problem.
2. To develop technical report writing and presentation of the students.

Course Outcomes:

1. Student should identify problem and decide scope of his dissertation work.
2. Student should complete literature review for dissertation work.

Guidelines

Candidates are required to do project during the entire second year of the course. The work is divided into two parts, project stage-I during the third semester and project stage-II during the fourth semester.
Candidates are required to solve/analyze a mechanical engineering problem or develop any innovative concept/design in mechanical engineering during this period. The problem can be solved/ analyzed with the help of experiments which can be performed on a specially developed set ups or modified existing set up. The work can be based on analysis of components/ subsystems/systems using softwares. The work can also be based on exhaustive numerical analysis. The work can be combination of experimentation and software/numerical analysis. The results obtained need to be validated.
It is expected that, following work be completed during project stage-I.
1. Defining objectives and scope of the project work.
2. Literature review to understand the issues related to the work.
3. Development of the experimental set up, procedure for the experimentation and calibration
of the instrument.
4. Study of different softwares to be used for the analysis.
5. Mathematical techniques required for the project work.
6. Sample reading or analysis of sample components needs to be done so as to become familiar with the set up/software/mathematical tools.

A mid semester review will be conducted to finalise the scope and objective of the project work. Project stage I examination will be conducted based on the work completed during this stage.

ME67701: Technical Seminar - II

Credits: 04 **Teaching Scheme: 2 hrs / Week**

Course Objectives:

i. To empower the student to learn beyond what is taught in class by reviewing literature available at large

ii. A student is expected to review research papers periodicals , magazines and review publications on the internet and in other electronic resources.

iii. Student is expected to present views coherently to produce a presentation concisely with the surveyed information under the direction of the research guide.

Course Outcomes:

Under the influence of the project guide -To engage the student directly or indirectly in research at different levels, from advancing their course materials, professional development, to funded research projects to advance the state of practice.

SCOPE

The scope of the technical seminar will include but not restricted to the discipline of work for the final year thesis The scope will include

Survey of patents,

Research journals books and databases

Field survey and site visit reports

Communication from experts .

Semester – IV

STRUCTURE – SEMESTER IV

Subject Code	Subject Name	Type	Teaching scheme (Hrs./week)		Assessment scheme					Credits
					ISA				ESA	
			Lect.	Practical	CT	MSE	HA	CA	ESE	
Semester –IV										
ME67703	Dissertation Stage II	Lab	-	8 #	-	-	-	-	100	25
Total				**8**						**25**

- Student is expected to work around 40 hours per week as Self Study

ME67703: Dissertation Stage II

Credits: 25 Teaching Scheme: 8 hrs/week (Practical)

Course Objectives:

1. To develop technical report writing and presentation of the students.
2. The student should be able to construct mathematical and experimental analysis of a practical problem.
3. The students should be able to analyze the simulation and experimental data and draw technical conclusions based on the same.

Course Outcomes:

1. Dissertation report with technical conclusions based on simulation and or experimental results.

Guidelines

Project stage II is essentially continuation of the project stage I. The objectives and scope of the project work are defined during the project stage I.

The problem is completely solved during the project stage II. The results obtained are to be validated during this stage of the project. In case of any innovative concept the work would include completely developing the component/product/ process etc. and proving the results. The project work can be presented during the examination conducted as per the institute norms. It is expected that at least one publication / presentation on any relevant platform to be made before final examination.