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**Elective – I**

ME554  Modern Engineering Materials
ME555  Geometrical Modeling and Applications
ME556  Synthesis and Kinematics of Mechanism

**Elective – II**

ME557  Robotics and Automation
ME558  Engineering Experimental Techniques
ME559  Industrial Tribology

**Elective – III**

ME565  Machine Tool Design
ME566  Simulation and Mathematical Modeling
ME567  Engineering Economics

**Elective – IV**

ME568  Advanced Machine Design
ME569  Design and Analysis of Experiments
ME570  Material Handling Equipment Design

**Open Elective**

ET 561  Soft Computing
CS559  Professional Ethics & Cyber Law
CS560  Web Technologies
EE572  Renewable Energy Technology
EE675  Renewable Energy Technology
GE611  Research Methodology
AM 641  Finite element methods for engineers
### GOVERNMENT COLLEGE OF ENGINEERING, AURANGABAD
(An Autonomous Institute of Government of Maharashtra)

#### Department of Mechanical Engineering
Teaching and Evaluation Scheme (w.e.f 2014-15)
ME (Part-Time) in Mechanical Design

<table>
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| SEMESTER II |                       |     |    |     |             |       |    |        |           |     |       |
| Elective - I (ME554 to ME556) |                | 4   | -  | -   | 4            | 20     | 20 | 60     | -         | -   | 100   |
| Elective - II (ME557 to ME559) |                  | 4   | -  | -   | 4            | 20     | 20 | 60     | -         | -   | 100   |
| ME560       | Lab – I                    | -   | -  | 2   | 2            | -      | -  | 50     | -         | -   | 50    |
| ME561       | Seminar – I                | -   | -  | 2   | 2            | -      | -  | 25     | 25        |      | 50    |
| Total of Semester - II          |                     | 8   | 4  | 12  | 40           | 120    | 75 | 25     | 300       |     |       |
| Total Credit Points            |                     |     |    | 12  |             |       |    |        |           |     |       |

| SEMESTER III |                       |     |    |     |             |       |    |        |           |     |       |
| ME562       | Finite Element Methods    | 4   | -  | -   | 4            | 20     | 20 | 60     | -         | -   | 100   |
| ME563       | Mechanical Vibrations Analysis |   |    |     |             |       |    |        |           |     |       |
| ME564       | Computer Aided Optimization| 4   | -  | -   | 4            | 20     | 20 | 60     | -         | -   | 100   |
| Total of Semester - III        |                     | 12  | -  | 12  | 60           | 60     | 180| -      | 300       |     |       |
| Total Credit Points            |                     |     |    | 12  |             |       |    |        |           |     |       |

| SEMESTER IV |                       |     |    |     |             |       |    |        |           |     |       |
| Elective–III (ME565 to ME567) |               | 4   | -  | -   | 4            | 20     | 20 | 60     | -         | -   | 100   |
| Elective – IV (ME568 to ME570) |                | 4   | -  | -   | 4            | 20     | 20 | 60     | -         | -   | 100   |
| ME571       | Lab - II                  | -   | -  | 2   | 2            | -      | -  | 50     | -         | -   | 50    |
| ME572       | Seminar – II              | -   | -  | 2   | 2            | -      | -  | 25     | 25        |      | 50    |
| Total of Semester - IV         |                     | 8   | 4  | 12  | 40           | 120    | 75 | 25     | 300       |     |       |
| Total Credit Points            |                     |     |    | 12  |             |       |    |        |           |     |       |

| SEMESTER V |                       |     |    |     |             |       |    |        |           |     |       |
| ET 561     | Institute Elective      | 4   | -  | -   | 4            | 20     | 20 | 60     | -         | -   | 100   |
| CS559      |                         |     |    |     |             |       |    |        |           |     |       |
| CS560      |                         |     |    |     |             |       |    |        |           |     |       |
| EE572      |                         |     |    |     |             |       |    |        |           |     |       |
| EE675      |                         |     |    |     |             |       |    |        |           |     |       |
| GE611      |                         |     |    |     |             |       |    |        |           |     |       |
| AM 641     |                         |     |    |     |             |       |    |        |           |     |       |
| GE 612     | Environment Studies     | 3   | 3  | -   | 20           | 20     | 60 | -      |           |     | 100   |
| ME611      | Dissertation Part - I   | -   | -  | 10  | 10           | -      | -  | 50     | 50        | 50  | 100   |
| Total of Semester - V          |                     | 4   | 10 | 17  | 20           | 20     | 20 | 50     | 50        | 50  | 100   |
| Total Credit Points            |                     |     |    | 17  |             |       |    |        |           |     |       |

<p>| SEMESTER VI |                       |     |    |     |             |       |    |        |           |     |       |</p>
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<td>ME565 Machine Tool Design</td>
<td>ME568 Advanced Machine Design</td>
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<td>ME566 Simulation and Mathematical Modeling</td>
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<td>GE611 Research Methodology</td>
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<td>AM 641 Finite element methods for engineers</td>
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ME551: MACHINE STRESS ANALYSIS

Teaching Scheme
Lectures: 4 hrs/week

Examination Scheme
Class Test – 20 marks
Teacher’s Assessment – 20 marks
End Sem Exam – 60 marks

Objectives:
To understand concepts of plain stress, strain, strain energy, two dimensional and octahedral stress conditions and applying it for numerical analysis. Enhancing torsion concepts for circular and non-circular cross sections and applying it to various experimental and numerical analysis. To understand concepts of shear centre and contact stresses in various geometric conditions and using it for numerical analysis.

Outcomes:
To develop ability of solving problems based on critical conditions of loading in two and three dimensional state, enhance the knowledge and ability of solving practical problems based on torsion, shear centre and contact stresses


Applications of Energy Methods: First and second theorems, Castigliano’s theorems, applications foe analysis of loaded members to determine deflections and reactions at supports.

Theory of Torsion: Torsion of prismatic bars of non-circular cross sections, Thin walled hollow and rectangular cross sections, Saint Venant’s theory, Prandtl’s membrane analogy, Kelvin’s fluid flow analogy, warping of the cross sections.

Experimental Stress Analysis: Stress analysis by – mechanical, optical and electrical strain gauges, strain rosette, whole field methods, Moire fringe method, brittle coatings for strain indication.

Shear Center and Unsymmetrical Bending: Shear center for beams of different cross sections, bending and deflections of beams subjected to unsymmetrical bending.

Contact Stresses: Hertz’s contact stresses, expression for principle stresses, deflection of bodies in point contact, stress in bodies in point and line contacts.

Reference Books
1. Timoshenko and Young, “Theory of Elasticity”, TMH Publications.
ME552: ADVANCED MATHEMATICAL METHODS

Teaching Scheme
Lectures: 4 hrs/week

Examination Scheme
Class Test – 20 marks
Teacher’s Assessment – 20 marks
End Sem Exam – 60 marks

Objectives:
We help the students to master their skills and improve their mathematical ability and maturity. The main objective of this course is to provide the student with a repertoire of mathematical methods that are essential to the solution of advanced problems encountered in the fields of engineering. In addition, this course is intended to prepare the student with mathematical tools and techniques that are required in advanced courses offered in the engineering programs.

Outcomes:
Application of the basic science systematization thought excavation, evaluation, diagnosis project question, and plans and carries out ability of the special study and the solution. Have independent research, collection of the data, standard problem development, acquire conclusion from data, and have development innovation and compose the ability of professional thesis. Use mathematics in engineering realm to do design and analysis, explanation of data obtained from experiments with independently ability to solve the problem.


Curve Fitting: Least square curve fitting procedures for straight line, Nonlinear curve fitting, weighted least square approximation, Method of least square for continuous function.

Finite Difference Methods: Formation of difference equation, linear difference equation, rules for finding out complementary function, rules for finding out particular integral, difference equations reducible to linear form, simultaneous difference equation with constant coefficients, application to deflection of a loaded string, loaded simply supported beams or cantilevers.

Reference Books


ME553: DESIGN ENGINEERING

**Teaching Scheme**
Lectures: 4 hrs/week

**Examination Scheme**
- Class Test – 20 marks
- Teacher’s Assessment – 20 marks
- End Sem Exam – 60 marks

**Objectives:**
To understand concepts of principal stresses, principal strain in tri-axial state conditions and applying it for numerical analysis. To understand behavior of material in fracture and applying various laws of fracture and its numerical analysis. To understand fatigue phenomenon of material and effect of various factor in fatigue and its numerical analysis. Know the plastic bending of material at various conditions. To understand the phenomenon of creep under temperature and multi-axial loading.

**Outcomes:**
To develop numerical ability of solving critical problems under tri-axial state of stress. Enhance the knowledge and numerical ability of phenomenon of fracture and fatigue at micro level conditions of loading. To able to solve practical problems of creep under low and high temperature. To able to solve practical problems on plastic bending.

**Fundamentals of Design Considerations:**
- Principle planes and principle stresses, tri-axial state of stresses, Mohr's circle for tri axial stresses and strains, volumetric strain, principle stresses computed from principle strains, principle strains due to perpendicular stresses and shear stresses, strain energy stored due to principle stresses in three directions, shear strain energy due to principle stresses.

**Fracture Mechanics:**

**Fatigue of Metals:**
- Fatigue phenomena, statistical nature, structural features, micro mechanisms: initiation and propagation, fatigue changes in different metals, fracture mechanism for fatigue, influential factors, effect of stress concentration, size effect, fatigue dislocation structure, fatigue crack growth, surface effects, corrosion fatigue, effect of mean stress on fatigue under multi-axial cyclic stresses, effect of metallurgical variables and temperature, fatigue of plastic and composites.

**Plastic Bending:**
The plastic flow process, shape factor, spring back, plastic bending with strain hardening material, plastic bending of wide plates, plastic hinges, and plastic deflection.

**Creep:**
Creep of material at high temperature, exponential creep law, and hyperbolic sine creep law, true stress and true strain, estimation of time to rupture, creep rupture testing, theories of low temperature and high temperature creep, presentation of creep data, prediction of long time properties, creep during bending, creep under multiaxial stresses, stress relaxation, creep during variable load or temperature, creep fatigue interaction, viscoelasticity, creep behavior of plastics.

**Reference Books:**
2. Timoshenko, “Strength of Materials”
ME554: MODERN ENGINEERING MATERIALS

Teaching Scheme
Lectures: 4 hrs/week

Examination Scheme
Class Test – 20 marks
Teacher’s Assessment – 20 marks
End Sem Exam – 60 marks

Objectives:
(1) Understand and analyze the structure and properties of ferrous and non-ferrous materials and their heat treatment processes.
(2) Analyse the properties and applications of composite material for different applications.
(3) Understand the structure and application of organic materials.

Outcomes:
(1) Analyze and predict the heat treatment process for a particular ferrous and nonferrous material.
(2) Prediction and analysis of composite material for different applications.
(3) To be able to select a material for design and construction.

Ferrous Materials: Mechanical properties, heat treatments and applications; stainless steel and heat resisting steels, precipitation hardenable steels, valve steels, high strength low alloy steel (HSLA), micro alloyed steels, ball bearing steel, tool steels, high nitrogen steels, alloy cast iron.

Nonferrous Materials: Mechanical properties, heat treatments and applications; copper alloys (Brasses and Bronzes), Al –alloys (Al-Mg-Si, Al-Cu, Al-Si), designation system in Al – alloys.

Composites: Classifications, properties, application of composites, polymer matrix materials, metal matrix materials, ceramic matrix materials, carbon materials, glass materials, fiber reinforcements, types of fibers, whiskers, laminar composites, filled composites, particulate reinforced composites

Design of composites materials: Hybrid composites, angle plied composites, mechanism of composites, calculation of properties, unidirectional fiber composites, critical volume fraction, discontinuous fiber composites, rule of mixtures equation, critical angle. Analysis of an Orthotropic Lamina, strengths of orthotropic lamina, analysis of Laminated Composites, stress strain variations in laminates,

Organic Materials: Classification, properties, application of polymers, plastics and elastomers. Ceramics: Classification, properties, structures of refractories, abrasive materials, electronic ceramics, cement and concrete.

Reference Books
5 Rajput R.K., Materials Science and Engineering, Kataria and sons.
ME555: GEOMETRICAL MODELING AND APPLICATIONS

Teaching Scheme
Lectures: 4 hrs/week

Examination Scheme
Class Test – 20 marks
Teacher’s Assessment – 20 marks
End Sem Exam – 60 marks

Objectives:
Acquire the knowledge of 2-D, 3-D transformations, projections and drawing of different curves. Enable to generate surfaces using algorithms. Use of algorithms for windowing, clipping, hidden line and surface removal

Outcomes:
Implementation of transformations in drawing projections and curves. Generate codes for surface generation, windowing, clipping, hidden line and surface removal.

Differential Geometry: 2D transformations: basic transformations, matrix representations and homogeneous coordinates, concatenated transformations, general pivot rotation and and scaling, general reflection through arbitrary line. 3D transformations: basic and general transformations, orthographic projections, auxiliary projections and perspective projections.

Curves: Plane curves: Curves representations, parametric and non-parametric representations of circle, ellipse parabola, hyperbola and cones. Space curves: representation of space curves, cubic splines, normalized cubic splines, parabolic bending, beginin curves and B-spline curves.

Surface Description and Generation: Surface revolution, sweep surfaces, quadric surfaces, piecewise surface representation, bilinear surfaces, ruled and developed surfaces, linear coons surfaces, coons bicubic surfaces, bezier surfaces, B-splines surfaces. Algorithms to draw 2-D primitives line and circle drawing algorithms and Bresenham’s algorithm.

Windowing and Clipping: Clipping algorithms, two-dimensional clipping, sutherland-cohen subdivision, line clipping algorithm and polygon clipping. 2-D and 3-D viewing, 3-D solid representation, basic modeling, and geometric algorithms, data structures and Boolean set operations

Hidden Line and Surface Removal Algorithms: Hidden Line and Surface Removal Algorithms, light color and shading, animation, virtual reality environment. Orientation of a few CAD packages

Reference Books
1. Faux, Prat, “Computational Geometry for Design and Manufacture”.
ME556: SYNTHESIS AND KINEMATICS OF MECHANISMS

Teaching Scheme
Lectures: 4 hrs/week

Examination Scheme
Class Test – 20 marks
Teacher’s Assessment – 20 marks
End Sem Exam – 60 marks

Objectives:
(1) To acquire the knowledge of kinematics and dynamics for various mechanisms in mechanical engineering
(2) To study and analysis various methods for synthesis

Outcomes:
(1) Enhancement of knowledge to apply the kinematics and dynamics principles for real mechanisms
(2) Increment in ability to solve various real practical problems.

Kinematics Analysis: Four bar coupler point curves, center of path, curvature of coupler points, Euler savary equations, collineation axis, Bobilier construction method, velocity and acceleration analysis of complex mechanisms by using short-cut methods.

Dynamics of four-bar mechanism: Dynamic analysis for static and inertia forces for a four bar mechanism, center of percussion, dynamically equivalent systems.

Geometrical methods of synthesis of planar mechanisms: Function generation with four-bar linkages, synthesis with three accuracy points and four accuracy points.

Analytical Methods: Displacement equation of a four-bar mechanism, synthesis for function or path generation, synthesis with prescribed velocities and acceleration, synthesis with four accuracy points, structural error curve, re-spacing analysis of mechanical errors in linkages, coupler synthesis.

Synthesis of spatial mechanisms: Matrix methods of analysis, faction generation for symmetric function.

Reference Books
1. Hartenbere R. S., Denauli J., “Kinematics Synthesis of linkages”
3. Bevan Thomas, “Theory of Machines”
4. Shigley J. E., “Theory of Machines”
5. Hirschhorn J., “Kinematics and Dynamics of the plane mechanisms”
6. Hall A. S., “Kinematics and Linkage Design”
# ME557: ROBOTICS AND AUTOMATION

## Teaching Scheme
Lectures: 4 hrs/week

## Examination Scheme
- Class Test – 20 marks
- Teacher’s Assessment – 20 marks
- End Sem Exam – 60 marks

## Objectives:
To understand robot anatomy and characteristic of different type, dynamic performance of robotic system and its kinematics. To know the different sensors, grippers their selection and dynamic performance analysis. To accustom with robot programming and its use in casting, welding, machining industry. To know the CNC, PLC and DC servo systems and machine interfacing.

## Outcomes:
To develop ability of analyzing robot performance, Applying knowledge for sensor and gripper selection, preparing for programming of PLC's for various industrial systems.

## Automation and Robotics:
Definition, need of the Robotics, market and future prospects, differentiation of Robots from other automation systems, near relations to robots, robot usages and conditions for its application, Robot Anatomy and Characteristics: Classification, point to point and continuous path system, control loops of robot system, work volume, speed of movement, dynamic performance, Accuracy and repeatability, drive system, sensors used in robotics, letter symbol, coding and kinematics arrangement

## Sensors and End Effectors in Robotics:
Tactile sensors, proximity and rear sensors, force and torque sensors in Robotics, End effectors: Functions, Types, Design of linkage type end effectors, Vacuum gripper, Magnetic gripper, Special gripper, Engelberger’s principles in selection and design of grippers

## Robot Programming And Application:

## CNC Systems And Robotics:
Various configurations, CPU, PLC’S, Servo control units, speed position feedback, Other peripheral devices, Tool monitoring controls, Softwares, User interface, PLC programming/DC servo motors, Relays and solenoid stepper motor, Introduction and configuration of the CNC system, Interfacing Monitoring diagnostics, Machine Data, Compensations for machine accuracies, Programming direct numerical control.

## Machine Interfacing:
Interfacing electro mechanical system to microprocessor, PC and PLC’s, Basic flow charts and programming for controlling machine tools and process parameters with the above systems, Study of various mechanical elements used in CNC: Robotics system viz-linear bearings, ball screws couplings.

## Reference Books
6. Handbook of Industrial Robotics
ME558: ENGINEERING EXPERIMENTAL TECHNIQUES

Teaching Scheme
Lectures: 4 hrs/week

Examination Scheme
Class Test – 20 marks
Teacher’s Assessment – 20 marks
End Sem Exam – 60 marks

Objectives:
To understand the concepts of calibrations, generalized measurement and experimental planning. To analyze the experimental data using various statistical techniques, writing reports. Measurement of parameters like force, torque, motion and vibration. Use of data acquisition system for processing the experimental data.

Outcomes:
Able to design, plan and execute experimental systems for particular engineering problems. Analyze and report performance of experimental systems.

Basic Concepts: Definition of terms, Calibration, Standards, Dimensions and units, the generalized measurement system, Basic concepts in dynamic measurements, system response, distortion, impedance matching, experimental planning.

Analysis of Experimental Data: Causes and types of experimental errors, uncertainty analysis, evaluation of uncertainties for complicated data reduction, Statistical analysis of experimental data, probability distributions, the Gaussian, normal error distribution, probability graph paper, the Chi-square test of Goodness of fit, The method of least squares, the correlation coefficient, standard deviation of the mean, t-distribution, Graphical analysis and curve fitting, general considerations in data analysis.

Force Torque and Strain Measurements: Mass balance measurements, elastic elements of force measurements, torque measurement, stress strain measurements, various types of strain gauges,

Motion and Vibration measurement: Simple vibration instruments, principles of the seismic instruments, practical considerations of seismic instruments, sound measurements.

Data Acquisition and Processing: The general data acquisition system, signal conditioning, data transmission, analog to digital and digital to analog conversions, data storage and display, the program as substitute for wired logic.

Reference Books

ME559: INDUSTRIAL TRIBOLOGY

**Teaching Scheme**
Lectures: 4 hrs/week

**Examination Scheme**
Class Test – 20 marks
Teacher’s Assessment – 20 marks
End Sem Exam – 60 marks

**Objectives:**
1. Understand different tribological properties and its behavior.
2. Study and analyze various lubrication methods under different loading conditions.
3. Study different types of lubricants, bearing material and its applications

**Outcomes:** Students will be able to
1. Analyze effects of various tribological properties
2. Apply various lubrication methods under different loading conditions

**Viscosity and Wear:** Definition, Petroff’s law, Hagen-Poiseuille law, variation of viscosity with temperature and pressure, viscosity index, effect of pressure on flow through slot. Types of wear, theories of friction and wear, dry friction and boundary friction, effects of bearing metal composition and wear.

**Hydrodynamic Lubrication:** Generalized Reynold’s equation, solution for long-finite and short tapered bearings, flow rate, eccentricity, hydro-dynamic thrust bearings, plain tapered land bearing, Rayleigh’s step bearings, behavior of hydro-dynamic bearings under variable loads, squeeze films, thermal equilibrium of sliding system, elasto- hydrodynamic lubrication.

**Hydrostatic Lubrication:** Pressure distribution in a simple hydrostatic thrust bearing, pumping power and pump capacity, hydrostatic formal bearings, hydrostatic thrust bearing with rotation and compensation.

**Gas Lubrication:** Merits and de-merits of gas lubrication, aerodynamic and aerostatic journal bearings, solution of Reynold’s Equation for gas bearings, load carrying capacity of aerostatic bearings.

**Lubricants and Bearing Materials:** Types, lubricating oils, composition, additive properties, testing of lubricants and selection of lubricants for various conditions. Desirable properties, white metals, bronzes, silver, aluminum alloys, Teflon, rubber, graphite.

**Reference Books**
1. Shaw and Mack, “Lubrication and Bearings”
2. Fuller D. D., “Theory of Lubrication”
3. Cameron, “Lubrication”
5. A.S.M.E. Handbooks
ME560: LABORATORY – I

Teaching Scheme
Tutorial: 2 hrs/week

Examination Scheme
Term Work – 50 marks

Objectives: Acquiring knowledge of writing codes for solving problems

Outcomes: Enhancing knowledge about writing codes for solving problems

The laboratory work will consist of development of codes for different numerical methods for learning purpose, chosen from those given in the contents of the Advanced Mathematical Methods syllabus.

Further, the lab hours shall be used for coding the algorithms developed for solution of any problem selected by student from the field of Mechanical Design.

ME561: SEMINAR – I

Teaching Scheme
Tutorial: 2 hrs/week

Examination Scheme
Term Work – 25 Marks
Viva voce – 25 marks

Seminar – I should be based on literature survey on any topic, which will lead to dissertation in that area. It will be submitted as a report of about 25 pages of ‘A4’ size sheets in either comb or hard bound.

The candidate will have to deliver a seminar presentation in front of the examiners, one of them will be guide and other will be the examiner appointed by DSB. The performance of the student will be evaluated by both examiners jointly based on the content of the seminar, delivery of seminar and answers to the queries of the examiners.

ME562 – FINITE ELEMENT ANALYSIS

Teaching Scheme
Lectures: 4 hrs/week

Examination Scheme
Class Test – 20 marks
Teacher’s Assessment – 20 marks
End Sem Exam – 60 marks

Objectives:-
1. Understand how and why finite element techniques work.
2. Learn how the finite element method is implemented.
3. Develop finite element formulations of engineering problems from a variety of application areas including structural mechanics, Heat transfer and fluid mechanics.
4. Understand how to use finite element analysis in design.

Outcomes: - Students will be able to
1. Develop finite element formulations of engineering problems and solve them.
2. Compute the Stiffness matrix, displacement transformation matrix.
3. Perform stress and thermal analysis using FEA.

Introduction: Basic concept, Historical background, engineering applications, general description, comparison with other methods, Need for weighted – integral forms, relevant mathematical concepts and formulae, displacement transformation matrix, stiffness matrix, weak formulation of boundary value problems, variational methods, Rayleigh –Ritz method and weighted residual approach

Finite Element Techniques: Model boundary value problem, finite element discretization, element shapes, sizes, and node locations, interpolation functions, shape functions, derivation of element equations, connectivity, boundary conditions, principal of potential energy,
FEM solution, post-processing, Compatibility and completeness requirements, convergence criteria, higher order and isoparametric elements, natural coordinates, Langrange and Hermit Polynomials

Applications to solid and structural mechanics problems: External and internal equilibrium equations, one-dimensional stress-strain relations, plane stress and strain problems, strain displacement relations, boundary conditions compatibility equations, analysis of trusses, frames and solids of revolution, computer programs.

Application to heat transfer problem: Variational approach, Galerkin approach, one-dimensional and two-dimensional steady state problems for conduction, convection and radiation

Application to fluid mechanics problems: In viscous incompressible flow, potential function and stream function formulation, incompressible viscous flow, stream function, velocity-pressure and stream function-vorticity formulation, solution of incompressible and compressible fluid film lubrication problems

Reference Books
3. Introductory Finite Element Method by Chandrakant S Desai, Tribikram Kundu
4. The Finite Element Method: Volume 2 by O C Zienkiewicz, R L Taylor

ME563: MECHANICAL VIBRATIONS AND ANALYSIS

Teaching Scheme
Lectures: 4 hrs/week

Examination Scheme
Class Test – 20 marks
Teacher’s Assessment – 20 marks
End Sem Exam – 60 marks

Objectives:-
1. Understand fundamental concepts of different types of vibrations.
2. Learn the behavior and response of various vibration systems.
3. Study and analyze continuous, self excited and non linear vibrations

Outcomes: - Students will be able to
1. Recognize and apply the fundamental concepts of vibrations to real systems
2. Analyze and find the solutions for different practical vibratory systems

Single Degree of Freedom Systems: Undamped vibrations, damped vibrations, forced vibrations. Types of damping, reciprocating and rotating unbalance, spring mass system, torsional vibrations, pendulums, transverse vibrations

Two Degree of Freedom Systems: Systems with two degree of freedom, determination of natural frequencies, principle modes of vibration, node point systems with rectilinear and angular modes, dynamic and centrifugal pendulum vibration absorbers, response of systems to forced vibrations, viscous and coulomb dampers. Lagrange’s equations and applications.


Vibrations Through Continuous Medium: Vibrations of systems having infinite degrees of freedom, vibrations of strings, longitudinal and transverse vibrations of rods and beams, torsional vibrations of shafts having different end conditions.
**Self-Excited and Non-linear Vibrations:** Criterion for stability, cause of instability, analysis of special cases of self excited vibrations: Free vibrations with non-linear elasticity and damping, relaxation oscillations, sub-harmonic response, phase-plane plots, perturbation techniques, Duffing’s equation, jump phenomenon etc.

**Reference Books**
1. Grover G. K., “Mechanical Vibrations”
3. Tse, Morse, Hinkle, “Mechanical Vibrations”
4. Hartog Den, “Mechanical Vibrations”
5. Church, “Mechanical Vibrations”

**ME564: COMPUTER AIDED OPTIMIZATION**

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<th>Teaching Scheme</th>
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<td>Lectures: 4 hrs/week</td>
<td>Class Test – 20 marks</td>
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<tr>
<td>Teacher's Assessment – 20 marks</td>
<td>End Sem Exam – 60 marks</td>
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**Objectives:**
1. Understanding and Analysis of optimisation problems.
2. Understanding of single variable and multi variable optimisation.
3. Analysis of problems within the defined limits.
4. System development and problem solving by using specific algorithms.
5. Modelling and performance analysis various optimisation methods.

**Outcomes:**
1. Comparative analysis of optimisation methods.
2. Analysis and use of single variable optimisation.
3. Understanding and Analysis of constrains in optimisation.

**Introduction:** Optimal problem formulation, engineering optimization problems, optimization algorithms.

**Single Variable Optimization Algorithms:** Optimality criteria, bracketing methods, region elimination methods, point estimation methods, gradient based methods, root finding using optimization techniques.

**Multivariable Optimization Algorithms:** Optimality criteria, unidirectional search, direct search methods, gradient based methods, Computer programs on above methods.

**Constrained Optimization Algorithms:** Kuhn-Tucker conditions, transformation methods, sensitivity analysis, direct search for constrained minimization, linearised search techniques, feasible direction method, generalized reduced gradient method, gradient projection method, Computer programs on above methods.

**Special Optimization Algorithms:** Integer programming, Geometric programming, Genetic Algorithms, Simulated annealing, global optimization, Computer programs on above methods.

**Optimization in Operations Research:** Linear programming problem, simplex method, artificial variable techniques, dual phase method, sensitivity analysis

**Reference Books**

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**ME565: MACHINE TOOL DESIGN**

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<td>End Sem Exam – 60 marks</td>
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**Objectives:**
Understand fundamental concepts machine tool drives, hydraulic transmission systems of machine tools, identify the forces in various machining operations, Carry out force Analysis professionally, Recognize and understand the standard speed and feed box design procedures for different machine tools. To acquire a skill to design and develop machine tool structure spindles and guide ways, CNC and DNC with practicing various analytical problems

**Outcomes:**
Recognize and apply the fundamental concepts of transmission system, Apply the knowledge of forces in machining to develop machine tool force diagrams, and improve analytical ability in professional practice in designing speed and feed boxes for various machine tools, Identify, Formulate Engineering problems in Machine tool Design, Enhance and develop professional skill of designing machine tool structures, spindles, guide ways of Universal, CNC and DNC machines

**Machine Tool Drives and Mechanism:** Machine tool drives, Hydraulic transmission, mechanical transmission, different types of driving mechanisms used in machine tools, requirements of machine tool design, force analysis in cutting in turning drilling and milling.

**Regulation of Speed and Feed Rates in Machine Tools:** Speed and feed rates regulation, design of speed box, design of feed box, Machine tool drives in multiple speed motors, special cases, gearing diagram, determination of number of tooth.

**Design of Machine Tool Structures and Guide ways:** Design criteria for machine tool structures, Static and Dynamic stiffness, Design procedure for design of bed, column, housing, bases and tables, Modern techniques in design of structures.

**Design of Guide ways, Power screws and Spindles:** Design of slide ways, design of aerostatic slide ways, combination guide ways, protecting devices of slide ways, design of power screws, design calculations of spindles. Antifriction bearings and sliding bearings, stability of machine tools, forced vibrations of machine tools

**Machine Tool Control and Advance Design:** Control systems for changing speed and feeds, automatic control of CNC machines, numerical control systems, design of NC and CNC machine tools

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**Reference Books**

ME566: SIMULATION AND MATHEMATICAL MODELING

Teaching Scheme
Lectures: 4 hrs/week

Examination Scheme
Class Test – 20 marks
Teacher’s Assessment – 20 marks
End Sem Exam – 60 marks

Objectives:
To gain knowledge of system development and simulation procedure, use of statistical model in simulation, and random number generation. To select input model and Validation by simulation. Carry out output analysis for a single model.

Outcomes:
To interpret the system environment and components, concepts of discrete simulation models. Illustrate the behavior of different simulation models, elaborate the characteristics and properties of random numbers using different techniques. Execution of input models with verification and validation by use of simulation. To do output analysis of single model.

Introduction to Simulation: System and system environment, Components of the system, Type of systems, type of models, steps in simulation, study advantages and disadvantages of simulation, concept of discrete simulation, time-advance mechanisms, components and organization of a discrete-event simulation model.

Statistical models in simulation: Useful statistical models, discrete distribution, continuous distribution, Poisson process, empirical distribution.
Queuing Models: Characteristics of queuing systems, queuing notations, long run measures, of performance of queuing systems, steady state behaviour finite population model.

Random number generation: properties of random numbers, generation of pseudo random numbers, techniques for random numbers generation, tests for random numbers.
Random variate generation: Inverse transform techniques, convolution method, acceptance rejection techniques.

Input Modeling: Data collection, identifying the distribution of data, parameter estimation, goodness of fit tests, selection of input model without data, multivariate and time series input model.
Verification and Validation of Simulation Model: length of simulation runs, validation.

Output Analysis for a Single Model: Types of simulations with respect to output analysis, stochastic nature of output data, measure of performance and their estimation, output analysis of terminating simulators, output analysis for steady state simulation. Case studies in simulation, orientation of simulation software such as GPSS.

Reference Books
ME567: ENGINEERING ECONOMICS

Teaching Scheme
Lectures: 4 hrs/week

Examination Scheme
Class Test – 20 marks
Teacher’s Assessment – 20 marks
End Sem Exam – 60 marks

Objectives:
To built up the knowledge of managerial economics and analysis of project considering economical concepts. Expertise in costing, finance and accounting related to the organization. Able to do corporate planning

Outcomes:
Implement the knowledge of managerial economics, costing, finance and cost accounting through analyzing engineering problems and economic analysis of projects.

Managerial Economics: The principle and use of economic analysis in engineering practice. Discounted cash flow analysis, corporate tax and investment, Depreciation and economic studies, replacement analysis, valuation of assets.

Economic analysis of projects, analysis of risks and uncertainty, elements of demand analysis and forecasting, theory of firm as owner and a producer, economics of scale, market model, production function, output and pricing decisions, long run and short sun cost curves

Costing and Finance: Review of double entry book keeping, preparation of ledger accounts, trial balance profit and loss account, balance sheet, income and expenditure account, fund flow analysis, analysis and interpretation of final accounts, ration analysis and inter firm comparison,

Cost account: Material and human resource accounting, overhead, fixed and variable costs, marginal costing, process costs, cost estimation and cost control,

Corporate Finance: Cost of capital and sources of funds, working capital management, budgeting and budgetary control

Corporate Planning: Corporate objectives, goals and policies, process of corporate planning, SWOT analysis, GAP analysis, strategy formulation, investment evaluation, capital budgeting, risk analysis, industrial dynamics.

Reference Books

5. Dean Joel, “Managerial Economics”, PHI, New Delhi
ME568: ADVANCE MACHINE DESIGN

**Teaching Scheme**
Lectures: 4 hrs/week

**Examination Scheme**
Class Test – 20 marks
Teacher’s Assessment – 20 marks
End Sem Exam – 60 marks

**Objectives:**
Understand the concept of optimization like PDE, SDE and LE in respect of tensile bar, torsional bar, beam etc. Carry out design analysis of Belleville spring, torsional bar and rectangular spring in axial and fatigue loading, work out analysis of advance cam profile and dynamics of high speed cam and stress and strain analysis of flat plate, isotropic elastic plate with and without aperture. Understand the concept of advanced machine design, QFD, functional approach, problem formulation etc.

**Outcomes:**
Apply the fundamental concept of optimization and carry out the optimum design of tensile bar, torsional bar etc. Analyze and design and formulate engineering problems on Belleville, torsional and square spring, torsional spring, advance cam curve, cam profile, polydyne, dynamic cam. Design and analyze flat plates at different temperature and different types of supports and loading.

**Optimum Design of Mechanical Elements:** Statistical consideration for factor of safety, relationship between actual load and load capability, selection of factor of safety based on percentage estimates for tolerances on actual load and load capability and where the occurrence of the failure phenomenon would be disastrous.

Optimum design for mechanical elements by considering adequate design, optimum design, P.D.E., S.D.E., limit equations, principles of optimum design with normal specifications, redundant specifications, incompatible specifications, optimum design of tensile bar, torsion shaft, beams, step shafts and with combined loading.

**Mechanical Springs:** Design of square or rectangular bar helical springs, Belleville springs, ring springs, torsion bar springs, theory of square or rectangular bar helical springs under axial loading, cone or flat disc spring theory.

**Cams:** Basic curves, cam size determination, calculating cam profiles, advance curves, polydyne cams, dynamics of high speed cam systems, surface materials, stresses and accuracy, ramps.

**Flat plate:** Stress resultants in a flat plate, kinematics strain-displacement, relations for plates, equilibrium equation for small displacement, theory of plates, stress-strain temperature relations for isotropic elastic plates, strain energy of a plate, boundary conditions for plates, Circular plates with hole and without hole with different types of support and loading.

**Advances in machine design:** Defining design, creativity, invention and innovation, design methodology, patterns of evaluation, design patents, functional approach, performance specifications, Quality Function Deployment, improvement of ideality, design strategy, problem definition, objective, top down and bottom up approaches, system, problem formulation, substance field analysis, morphological analysis, creative problem solving, inventive principle, evaluation of ideas or concepts, product design specifications, selection of best design,

**Reference Books**
2. Wahl A.M., “Mechanical springs”
ME569: DESIGN AND ANALYSIS OF EXPERIMENTS

Teaching Scheme
Lectures: 4 hrs/week

Examination Scheme
Class Test – 20 marks
Teacher’s Assessment – 20 marks
End Sem Exam – 60 marks

Objectives:
Able to understand the fundamental concepts and principles of designing of experiments, sampling and sample selection as per DOE methods, carry out analysis of variance for single factor. Recognize and perform statistical analysis by using different methods. Acquire a skill of second and third factorial design by fitting response curve and surfaces at two and mixed level, analyze and form mathematical model by using DOE technique.

Outcomes:
Recognize and apply DOE guidelines for sampling, sample distribution etc. Apply the knowledge of analysis of variance, factorial design of second and third level parameters for building mathematical model. Enhance and develop professional skill and mixed level for experimental analysis

Introduction: Applications of experimental design, basic principles and guidelines for designing experiments, simple comparative experiments, sampling and sampling distribution, inferences about the differences, in means, randomized designs, paired comparison designs, variances of normal distribution.


Randomized Blocks, Latin Squares, and related designs: The randomized complete block design, statistical analysis of the RCBD, the Latin square design, the Graeco-Latin square design, balanced incomplete block design.

Factorial Designs: the advantages of factorial designs, $2^k$ and $3^k$ factorial design, model accuracy checking, estimating the model parameters, fitting response curves and surfaces, blocking in factorial design, blocking and compounding in the $2^k$ and $3^k$ factorial design, two level fractional factorial design, factorials with mixed levels.

Fitting Regression Models: Linear regression models, estimation of parameters in LRM, hypothesis testing and confidence intervals in multiple regressions, regression model diagnostics, testing for lack of fit.

Taguchi Method: Taguchi method as a new approach to DOE, application procedures, analysis and areas of application.

Reference Books
ME570: MATERIAL HANDLING EQUIPMENT DESIGN

Teaching Scheme
Lectures: 4 hrs/week

Examination Scheme
Class Test – 20 marks
Teacher’s Assessment – 20 marks
End Sem Exam – 60 marks

Objectives:
Understand functions, characteristics and applications of different material handling systems. Carry out kinematic and dynamic analysis of cranes, elevators and conveyors.

Outcomes:
Implement the knowledge of material handling systems in industries. Analyze the kinematic and dynamics of cranes, elevators and conveyors.

Introduction: Objectives of material handling systems and the basic principles, classification and selection of material handling equipment, Characteristics and applications.

Description of various material handling equipments, functions and parameters, effecting service, packaging and storage of materials and their relations with material handling.

Theory construction of various components, parts of mechanical handling devices, wire ropes, chains, hooks, shackles, grabs, ladles and lifting electromagnets, pulleys, sheaves, shears, sprockets, and drums, winches, brakes and ratchet stops, gears and power transmission systems, runner wheels and rails, buffers and controls of travel mechanisms.

Kinematic and dynamic analysis of various types of cranes and elevators, stability and structural analysis, discussion of principles and applications of conveyors and related equipments.

Design of various types of conveyors and their elements, fault finding and failure analysis of material handling systems, system design and economics.

Reference Books

ME571: LABORATORY – II

Teaching Scheme
Tutorial: 2 hrs/week

Examination Scheme
Term Work – 50 marks

Objectives: Acquiring knowledge of report writing.

Outcomes: Enhancing knowledge about writing reports.

The laboratory work will consists of assignment on report writing, various norms to be followed for report writing, paper writing and presentations. The use of report writing software shall be followed for writing reports.
ME572: SEMINAR – II

Teaching Scheme
Tutorial: 2 hrs/week

Examination Scheme
Term Work – 25 Marks
Viva voce – 25 marks

Seminar – II should be based on literature survey on any topic preferably in continuation with the Seminar – I. It will be submitted as a report of about 25 pages of ‘A4’ size sheets in either comb or hard bound.

The candidate will have to deliver a seminar presentation in front of the examiners, one of them will be guide and other will be the examiner appointed by DSB. The performance of the student will be evaluated by both examiners jointly based on the content of the seminar, delivery of seminar and answers to the queries of the examiners.

GE611: RESEARCH METHODOLOGY

Teaching Scheme:
Theory: 4 hours/week

Examination Scheme:
Class Test: 20 Marks
Teacher’s Assessment: 20 Marks
End Sem Exam: 60 Marks

Objectives:
The objective of this course is to expose the post graduate students to basic methodologies and techniques of carrying out research work which will be helpful for Dissertation work.

Outcomes:
Selection of research problem, formulation, analysis and report writing of work undertaken

Unit-I

Unit-II

Unit-III

Or

Unit-III
**Modeling and simulation:**
Introduction to modeling: Concept of system, continuous and discrete systems.
Experimental Methods:
Importance of experimental analysis, guidelines for designing experiments, uncertainty and error analysis, concept of uncertainty, propagation of uncertainty, planning experiments from uncertainty analysis.

**Unit-IV**

**Unit-V**

**References:**

The dissertation shall consist of a report on any research work done by the candidate or a comprehensive and critical review of any recent development in the subject or detailed report of the project work consisting of a design and/or development work that the candidate has executed. The dissertation will consist of two parts as dissertation part-I and dissertation II

**Term work**

The dissertation part I will be in the form of seminar report on the dissertation work being carried out by the candidate and will be assessed by two examiners appointed by the DSB, one of whom will be the guide and other will be a senior faculty member from the department.

**Practical /Oral**

The oral examination will be based on presentation on the dissertation work being carried out by the candidate and will be assessed by two examiners appointed by the DSB, one of whom will be the guide and other will be a senior faculty member from the department.
GE 612: ENVIRONMENTAL STUDIES

Unit 1: The multidisciplinary nature of environmental studies
Definition, scope and importance, Need for public awareness.

Unit 2: Natural Resources
Renewable and non renewable resources:
  a) Natural Resources and associated problems
     - Forest resources: Use and over-exploitation, deforestation, case studies, Timber extraction, mining, Dams and their effects on forests and tribal people.
     - Water resources: Use and over utilization of surface and water, floods, drought, and conflicts over water, dam’s benefits and problems.
     - Food Resources: World food problems, changes caused by agriculture and over grazing, effects of modern agricultures, fertilizers-pesticides problems, water logging, salinity, case studies.
     - Energy Resources: Growing energy needs, renewable energy sources, use of alternate energy sources, case studies.
     - Land Resources: land as resources, land degradation, man induces landslides, soil erosion, and desertification.
  b) Role of individuals in conservations of natural resources.
  c) Equitable use of resources for sustainable life styles.

Unit 3: Eco systems
   - Concepts of an Eco systems
   - Structure and function of Eco systems
   - Procedure, consumers, decomposers.
   - Energy flow in the Eco systems
   - Ecological suggestions
   - Food chain, food webs and ecological pyramids
   - Introduction, types, characteristics features, structure and function of the following eco systems
     - Forest eco systems
     - Grass land eco systems
     - Desert eco systems
     - Aquatic eco systems(ponds, streams, lake, rivers, oceans, estuaries)

Unit 4: Biodiversity and its conservation
   - Introduction- Definition: genetics, species and eco systems diversity
   - Biogeographically classification of India
   - Value of biodiversity: Consumptive use, productive use, social, ethical,ascetics and option values
   - Biodiversity at global, national and local level.
   - India as a mega diversity nation.
   - Hot-spots of Biodiversity
   - Threats to Biodiversity: habitat loss, poaching of wildlife, man wildlife conflicts
   - Endangered and endemic spaces of India
   - Conservation of Biodiversity: in-situ and ex-situ conservation of Biodiversity

Unit 5: Environmental Pollution
   Definition Causes, effects and control measures of:
     a. Air pollution
     b. Water pollution
     c. Soil pollution
     d. Marine pollution
     e. Noise pollution
     f. Thermal pollution
     g. Nuclear Hazards

   Solid waste management: Causes, effects and control measures of urban and industrials wastes
   Role of an individual in prevention of pollution
Pollution case studies
Disaster management: Floods, earthquake, cyclone and land slides

**Unit 6: Social issues and the environment**
- Form unsustainable to sustainable development
- Urban problems related to energy
- Water conservation, rain water harvesting, water shed management
- Resettlement and rehabilitation of people: its problems and concerns, case studies
- Environmental ethics: issues and possible solutions
- Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust, case studies
- Waste land reclamation
- Consumerism and waste products
- Environment protection act
- Air (prevention and control of pollution) act
- Water (prevention and control of pollution) act
- Wild life protection act
- Forest conservation act
- Issues involved in enforcement of environmental legislations
- Public awareness

**Unit 7: Human population and the environment**
- Population growth and variation among nations
- Population explosion – family welfare program
- Environment and human health
- Human rights
- Value education
- HIV/AIDS
- Women and child welfare
- Role of information technology in environment and human health
- Case studies

**Unit 8: Field work**
Visit to a local area to document environment Assets River / forest / grassland / hill / mountain. Visit to a local polluted site – urban / rural / industrial / agricultural. Study of common plants, insects, birds. Study of simple ecosystems – pond, river, hills lopes, etc. (field work equal to 5 lecture works)

**Recommended Books:**
1. Textbook of Environmental studies, Erachbharucha, UGC
2. Fundamental concepts in Environmental Studies, D D Mishra, S Chand & Co. Ltd.
ME612: DISSERTATION PART – II

Teaching Scheme
Tutorial: 24 hrs/week

Examination Scheme
Term Work – 50 marks
Viva voce – 150 marks

The dissertation part – II will be in continuation of dissertation part – I and shall consist of a report on the research work done by the candidate or a comprehensive and critical review of any recent development in the subject or detailed report of the project work consisting of a design and / or development work that the candidate has executed. The examinee shall submit the dissertation in triplicate to the head of the institution duly certified by the guide and the concerned head of department and the principal that the work has been satisfactorily completed.

Term work

The dissertation will be assessed by two internal examiners appointed by the DSB, one of whom will be the guide and other will be a senior faculty member from the department.

Viva voce

It shall consists of a defense presented by the examinee on his work in the presence of examiners appointed by the DSB, one of whom will be the guide and other will be an external examiner.