FACULTY OF ENGINEERING

Syllabus for the

M.E. (Mechanical – Design Engineering)

(w.e.f. 2008-2009)

UNIVERSITY OF PUNE
THE SYLLABUS IS PREPARED BY:

BOS-Mechanical Engineering
University of Pune

PEER REVIEW BY:

• Prof. P.V. Mandke
• Prof. V.B. Devarchetti
• Prof. Dr. S. Y. Bhave
• Prof. Dr. D.K. Joshi
• Prof. Dr. S. K. Basu

Note: This Syllabus is subjected to change without prior notice by the concerned BOS
Minutes of Meeting

Minutes of Meetings of the Peer View Committee on M. E. (Mechanical) in Design Engineering, Mechatronics and Heat Power Engineering courses held at Sinhgad College of Engineering, Pune and PVG College of Engineering dated 19th April 2007, 6th October 2007 and 10th January 2008

A separate peer view committees for these above courses were formed and long discussion on the syllabus framing was take place. Following points were discussed and following resolutions were resolved.

1. Mathematics and Management subjects are included for all courses as suggested by Dean Faculty Engineering and Academic Council.
2. Credit system and audit course concepts are incorporated.
3. Topics on Elastic behaviour of anisotropic material and introduction to fracture mechanics are added while plastic bending is being deleted from subject Advanced stress analysis.
4. Topics on ‘Multi degree freedom system, transfer matrix method, impulse response’ are included and ‘Dunkerley’s method, Stodola’s method’ are deleted in subject Vibration and Noise Control.
5. Cam shaft design with valve opening mechanisms, piston, and connecting rod are added in Advanced Machine Design.
6. Project evaluation should be carried out on following points.
   1. selection of Project
   2. Selection of components
   3. costing
   4. specification developments
   5. testing and verification
7. First should have general seminar and second & third seminar should be on project topic and evaluated as term work.
8. Industrial visits should be incorporated in Lab Practices.
9. Dissertation should not be accepted for evaluation until all theory subjects were cleared by the concerned candidate.
10. Topic on ‘Onsager equation, energy analysis of thermal systems’ is added in Advanced Thermodynamics.
11. 50 to 60% marks are kept for quantitative questions.

Date: 4th April 2008
Place: Pune

Coordinator
M. E. Syllabus Co ordination committee
Program Structure for  
M.E. Mechanical (Design Engineering)  
(For 2008 Course) (w.e.f. June – 2008)

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Subject</th>
<th>Teaching Scheme</th>
<th>Examination Scheme</th>
<th>Credits</th>
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<tr>
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<td>Lect.</td>
<td>Pract.</td>
<td>Paper</td>
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*The term work of project stage II of semester IV should be assessed jointly by the pair of internal and external examiners, along with oral examination of the same.

**Note:** The Contact Hours for the calculation of load of teacher
- Seminar - 1 Hr / week / student
- Project - 2 Hr / week / student
<table>
<thead>
<tr>
<th>CODE</th>
<th>Elective – I</th>
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<tr>
<td>502204 A</td>
<td>Instrumentation &amp; Automatic Control</td>
<td>502205 A</td>
<td>Material Handling Equipment Design</td>
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<td>502204 B</td>
<td>Advance Material Science</td>
<td>502205 B</td>
<td>Process Equipment Design</td>
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<td>Optimization Techniques</td>
<td>502205 C</td>
<td>Robotics</td>
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<tr>
<td>502211 A</td>
<td>Reliability Engineering</td>
<td>502212 A</td>
<td>Vehicle dynamics</td>
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<tr>
<td>502211 B</td>
<td>Engineering Fracture Mechanics</td>
<td>502212 B</td>
<td>Industrial Tribology</td>
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<tr>
<td>502211 C</td>
<td>Computer Aided Engineering</td>
<td>502212 C</td>
<td>OPEN (SELF STUDY)**</td>
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**Open elective subjects- BOS Mechanical Engineering will declare the list of subjects which can be taken under open elective.**
Mathematical Modeling and Analysis
(502201)

Teaching Scheme
Lectures: 3 Hrs per week

Examination Scheme:
Paper: 100 Marks
Paper Duration: 3 Hrs.

1. Concept of State
System, Environment and Variables. The state of a system, mathematical models of continuous line linear lumped parameter time invariant systems, Discrete time systems, linear approximation of non-linear systems, Topological Models of system, Block diagram representation, signal flow graph, Mason's rule.

2. A Generalized Approach to Modeling
The principles of conservation and continuity. Physical laws. Mechanical systems, Electrical and Electro mechanical systems, Fluid systems, Thermal systems.

3. Modeling of Physical systems
The linear graph approach. Linear Graph Terminology, Formulation of system equations, systems with multi terminal components. Linear Graph Models: Skeletal structures, Mass Transfer Processes.

4. Input output approach
Discrete Signal Models, Discrete time-convolution, response of linear Discrete time systems, continuous (Analogue) signal models, continuous time convolution, Response of linear continuous time state equation - Discrete time systems, computation of state transition matrix by canonical Transformation, Computation of state transition matrix by technique based on Caley-Hamilton theorem, the solution of state equation-continuous time systems,

5. Numerical Analysis

6. The Laplace Transform:
Application of Laplace transforms to differential equations, stability in s domain. Linear system, Laplace transform analysis of causal periodic input to linear systems. Relationship of the Z-Transform to the Fourier and Laplace transforms.

7. The Fourier Transform
Fourier spectra of power signals, Fourier transform of periodic functions- Fourier series, Fourier analysis of sampled signals, modulation, discrete Fourier transforms.

8. The Z Transform

9. Wavelet Transform
Multi resolution Analysis and construction of wavelets. Representation of functions by wavelets.
The characterization of MRA wavelets.

10 Simulation:
Introduction to simulation: Digital and Analogue simulation, Analytic and Monte Carlo simulation, Stochastic and Deterministic simulation.
Random and pseudo random number generation.
Designing a simulation experiment. Simulating basic stochastic models. Simulator technology.
Applications.
Text/References

Advanced Stress Analysis
(502202)

Teaching Scheme
Lectures: 3 Hrs per week

Examination Scheme:
Paper: 100 Marks
Paper Duration: 3 Hrs.

1. Theory of Elasticity:--
Analysis of stress, Analysis of stain, Elasticity problems in two dimension and three dimensions, Mohr’s circle for three dimensional stresses. Stress tensor, Airy’s stress function in rectangular & polar coordinates. Energy method for analysis of stress, strain and deflection The three theorem’s -theorem of virtual work, theorem of least work, Castigliano’s theorem, Rayleigh Ritz method, Galekin’s method, Elastic behaviour of anisotropic materials like fiber reinforced composites.

2. Theory of Torsion:--
Torsion of prismatic bars of solid section and thin walled section. Analogies for torsion, membrane analogy, fluid flow analogy and electrical analogy. Torsion of conical shaft, bar of variable diameter, thin walled members of open cross section in which some sections are prevented from warping, Torsion of noncircular shaft.

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

4. Plate bending: -
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 loaded symmetrically w. r. t. center, Bending of circular plates of variable thickness, circular plate with circular hole at centre symmetrically loaded and load distributed along inner and outer edges.

5. Pressurized cylinders and rotating disks:--
Governing equations, stress in thick walled cylinder under internal and 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, Plastic action in thick walled cylinders and rotating disc.

6. Contact stresses:--
Geometry of contact surfaces, method 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.

7. Introduction to Fracture Mechanics and Plastic Bending:--
Introduction to Linear Elastic Fracture Mechanics, Modes of fractures, Stress intensity factor, crack initiation and Crack opening phenomenon, stress distribution around crack tip under various loading conditions, Fracture toughness $G_{lc}$ Plastic bending of elastic materials, Post yield stress analysis, plastic flow process, shape factor, spring back effect.

8. Experimental stress analysis:
Dimensional analysis, analysis techniques strain gauges: configuration, instrumentation, characteristics of strain gauge measurement. Theory of photoelasticity and techniques used in photoelastic application

**Term Work**

**Exercise / Assignments for Laboratory Practice – I**

**A) Study and report on:-**
1. Study of strain Gauge Bridge.
2. Study of practical on photo elasticity
3. Study of plastic bending and spring back.

**B) Mini project:-**
On FEM analysis of machine members by using reputed commercial software for stress distribution, stress concentration and report writing on results of analysis.

**Reference Books**

1. Advanced Mechanics of Materials – Cook and Young, Prentice Hall
3. Advanced Mechanics of Materials – Boresi, Schmidt, Sidebottom, Willey
7. Experimental Stress Analysis – Dally & Riley
Technology and Financial Management
(502103)

Teaching Scheme: Lecture: 3 hrs/week
Examination Paper: 100 Marks
Paper Duration: 3hrs

Finance:
- Functions
- Source of finance
- National & International finance
- Benefits & Limitations
- Budgets & Budgeting Control

Costing:
- Significance of engineers
- Traditional absorption costing
- Marginal costing
- Contract costing
- Activity based costing
- Process costing

Engineering Economic Analysis:
- Basic concepts & price theory
- Supply & Demand
- Consumer behaviour
- Law of reducing returns
- Competition- types, equilibrium
- Inflation & unemployment
- Foreign trade
- Balance of payment

Quality Management:
- Fundamentals of TQM, Deming, Juran
- Kaizen
- JIT
- ISO 9000
- ISO 14000
Project Management:
- Project life cycle
- CPM
- PERT
- BOT
- Public Private Participation

HR Management:
- Difference between personnel management & HR management
- Role of HR Manager
- Manpower planning
- Merit rating
- Training & Development
- Retirement & Separation
- Organizational Development & Behaviour
- Management by objectives

Books:
1) S C Kuchal, Indian Economics
2) Prasad N K, Cost Accounting, Book Syndicate Pvt. Ltd., Kolkata 700 009
4) E Dessler, Human Resource Management
5) R S Dwivedi, Managing Human Resporces
6) Chase Operations Management for Competitive Advantage
7) B S Sahay, World Class Manufacturing
8) Juran, Quality Control Handbook
9) K Ishikawa, Guide to Quality Control
Instrumentation & Automatic Control (Elective – I)  
(502204-A)

**Teaching Scheme**
Lectures: 3 Hrs per week

**Examination Scheme:**
Paper: 100 Marks  
Paper Duration: 3 Hrs.

1) Introduction to measurements for scientific and engineering application need and goal.  
   Broad category of methods for measuring field and derived quantities.

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

3) Measurement of field quantities, thermometry, heat flux measurement, measurement  
   of force, pressure, flow rate, velocity, humidity, noise, vibration, measurement of the  
   above by probe and non instructive techniques.

4) Measurement of derived quantities, torque, power, thermo physical properties, radiation  
   and surface properties.

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

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

**Exercise/Assignment**

1) Calibration of pressure gauge  
2) Computer aided experimentation for temperature measurement.  
3) Design of control system for boiler/compressor/pumps/turbines  
4) Problem of analysis of data and error estimation.

**Reference Books**

   Publishing Co.

2) Beckwith TG. N. Lewis Buck and Marangoni R.D: Mechanical Measurements,Narosa  
   Publishing House,New Delhi

3) Liptak B.G. Instrument Engineers’ Handbook

4) Bolton W, Mechatronics-Electronics Control Systems in Mechanical and Electrical  
   Engg.

5) Modern Electronic Instrumentation and Measurement Technique by A.D. Helfrick and  
   W.D. Cooper

6) Johnson C.D., Process Control Instrumentation

   Seventh Edition
Advance Material Science (Elective –I)  
(502204-B)

Teaching Scheme
Lectures: 3 Hrs per week

Examination Scheme:
Paper: 100 Marks
Paper Duration: 3 Hrs.

1. 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


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

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

5 Composites, ceramics, cermets, shape memory alloys their manufacturing techniques, advantages and limitations.

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

Lab Practices:-

1. Study of effect of various coatings rates on steel samples by microscopy (Min. 4 studies)
2. Study of effect of various heat treatments on microstructures of non ferrous alloys (Min. 4 samples)

Reference Books

2. Elements of Material Science and Engineering, Lawrence H., Van Vlack Addison-Wesley Publishing Company
8. Biomaterials and Bioengineering Handbook, Donald L. Wise, Marcel Dekker Inc.
Optimization Techniques (Elective –I)  
(502204-C)

Teaching Scheme  
Lectures: 3 Hrs per week

Examination Scheme:  
Paper: 100 Marks  
Paper Duration: 3 Hrs.

**Introduction to Optimization:** Engineering applications of optimization, statement of optimization problem, classification of optimization problem

**Classical Optimization Techniques:** Introduction, single variable optimization, multi variable optimization with no constraint, equality constraint, in equality constraint, convex programming problems

**Linear programming:** Standard form of linear programming, geometry of linear programming, solutions of system of linear simultaneous equations, pivotal reduction of general system of reduction and simplex algorithms

**Non-linear programming:** One dimensional Minimization methods, elimination methods, unrestricted search, exhaustive search, half interval method, golden section method, Interpolation methods, Newton method, Quasi Newton method, secant method

**Non-linear programming (Unconstrained optimization techniques):** Direct search method, random search method, grid search method, Powell’s method, Simplex method. Indirect Search method, gradient of functions, descant method, conjugate gradient method, Newton’s method, Quasi Newton method

**Non-linear programming (Constrained Optimization):** Direct methods, random search method, complex method, sequential linear programming, sequential quadratic programming and generalized reduced gradient method, Indirect method- Penalty function methods

**Reference Books:**

3. Practical Methods of optimization, Fletcher, R., John Wiley  
1. Elements of Material Handling System:-
Importance, Terminology, Objectives and benefits of better Material Handling; Principles and features of Material Handling System; Interrelationships between material handling and plant layout, physical facilities and other organizational functions; Classification of Material Handling Equipments.

2. Selection of Material Handling Equipments:-
Factors affecting for selection; Material Handling Equation; Choices of Material Handling Equipment; General analysis Procedures; Basic Analytical techniques; The unit load concept; Selection of suitable types of systems for applications ; Activity cost data and economic analysis for design of components of Material Handling Systems; functions and parameters affecting service; packing and storage of materials.

3. Design of Mechanical Handling Equipments:-
[A] Design of Hoists:-
Drives for hoisting, components, and hoisting mechanisms; rail traveling components and mechanisms; hoisting gear operation during transient motion; selecting the motor rating and determining breaking torque for hoisting mechanisms.

[B] Design of Cranes:-
Hand-propelled and electrically driven E.O.T. overheat Traveling cranes; Traveling mechanisms of cantilever and monorail cranes; design considerations for structures of rotary cranes with fixed radius ; fixed post and overhead traveling cranes; Stability of stationary rotary and traveling rotary cranes.

4. Design of load lifting attachments:-
Load chains and types of ropes used in Material Handling System; Forged, Standard and Ramshorn Hooks; Crane Grabs and Clamps; Grab Buckets; Electromagnet; Design consideration for conveyor belts; Application of attachments.

5. Study of systems and Equipments used for Material Storage:-
Objectives of storage; Bulk material handling; Gravity flow of solids through slides and chutes; Storage in bins and hoppers; Belt conveyors; Bucket-elevators; Screw conveyors; Vibratory Conveyors; Cabin conveyors; Mobile racks etc.

6. Material Handling / Warehouse Automation and Safety considerations:-
[A] Storage and warehouse planning and design; computerized warehouse planning; Need, Factors and Indicators for consideration in warehouse automation; which function, When and How to automate; Levels and Means of Mechanizations.
[B] Safety and design; Safety regulations and discipline.

**Term Work:**

- **Following assignments comprise the laboratory practice:-**

  1. Design and development on Material Handling Equipments applicable to various process industries such as Sugar Industry, Power plants, Automobile manufacturing, Harbor, Foundries etc.

  2. Report based on visits to industries manufacturing or using various Material Handling Equipments.

**Reference Books**

Process Equipment Design (Elective-II)  
(502205-B)

Teaching Scheme
Lectures: 3 Hrs per week

Examination Scheme:
Paper: 100 Marks
Paper Duration: 3 Hrs.

1) **Process Design Parameters**: Basic concepts in process design, block diagrams for flow of processes, material flow balance. Design pressures — temperatures, design stresses, factory of safety, minimum shell thickness and corrosion allowance, weld joints efficiency, design loading, stress concentration and thermal stresses, failure criteria, optimisation technique such as Lagrange’s multiplier and golden section method, cost and profitability estimation. Introduction to design codes like IS-2825, ASME-SECTION VIII-DIV-2, TEMA, API-650, BS-1500 & 1515.

2) **Design of Cylindrical and Spherical Vessels**: 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.

3) **Design of Tall Vessels and Large Storage Tanks**: Determination of equivalent stress under combined loadings including seismic and wind loads application of it to vertical equipment like distillation column.

4) **Design of Thick Walled High Pressure Vessels**: Design by various theories of failure, construction of these vessels with high strength steel and other special methods.

5) **Process Equipment Design**: 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.

6) **Process Piping Design**: 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.

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

8) **Process Control**: Fundamentals of process measurements and control modern control devices and other controls of major unit operation and processes.

9) Applications of CAD to process Equipment Design.
TERM WORK

Following assignments / experiments comprise the laboratory practice :-

1) Design and optimisation of tall vessels and large tanks.
2) Design of Heat exchangers used in industries.
3) Design of crystallisers.
4) Design and development of equipment useful to process industries such as sugar, cement, chemical industries.
5) Preparing flow diagrams of processes, piping layout, etc.
6) Report based on visit to industries such as sugar, cement, chemical industries.

REFERENCE BOOKS

2) Process Equipment Design : By Browell and Young, John Wiley.
4) Industrial Instrumentation servicing Hand Book : Cannel Grady, McGraw Hill.
5) Handbook of Instrumentation and Control : Kellen Heward, McGraw Hill.
7) Chemical Equipment Design : B.C. Bhattacharya.
10) Pressure Vessel Design Hand Book : H. Bedna.
18) Control Devices, Vol. I and II : Liptak
Robotics (Elective – II)
(502205-C)

Teaching Scheme
Lectures: 3 Hrs per week

Examination Scheme:
Paper: 100 Marks
Paper Duration: 3 Hrs.

**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. Drives used in robots- Hydraulic, Pneumatic and Electric drives, Comparison of drive systems and their relative merits and demerits.

**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.

**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.

**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 & trapezoidal velocity strategy for robots.

**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, laser range finder, camera. Micro-controllers, DSP, centralized controllers, real time operating systems.

**Robot Controllers:-**
Essential components-Drive for Hydraulic and Pneumatic actuators, H-bridge drives for Dc motor Overload over current and stall detection methods, example of a micro-controller/ microprocessor based robot Controller.
Robot Vision:-
Introduction, Image acquisition, Illumination Techniques, Image conversion, Cameras, sensors, Camera and system interface, Frame buffers and Grabbers, Image processing, low level & high level machine vision systems.

Robot Programming languages:-
Introduction the three level of robot programming, requirements of a robot programming language, problems peculiar to robot programming languages.

Futuristic topics in Robotics:-
Micro-robotics and MEMS (Microelectro mechanical systems), fabrication technology for Micro-robotics, stability issue in legged robots, under-actuated manipulators, telecheirs.

Suggested References:
# Vibration & Noise Control

**Teaching Scheme**
Lectures: 3 Hrs per week

**Examination Scheme:**
Paper: 100 Marks
Paper Duration: 3 Hrs.

1. **(A) Multi Degree Freedom System:**

2. **(B) Multi Degree System Numerical Methods:**

3. **Continuous System:**
   - Vibrations of String, Bars, Shafts and beams, free and forced vibration of continuous systems.

4. **Transient vibrations:**
   - Response of a single degree of freedom system to step and any arbitrary excitation, convolution (Duhamel’s) integral, impulse response functions.

5. **Vibration Control:**
   - Balancing of rotating machine, In-situ balancing of rotors, control of natural frequency introduction of damping, vibration isolation & vibration absorbers.

6. **Vibration Measurement:**

7. **Random Vibrations:**
   - Expected values auto and cross correlation function, Spectral density, response of linear systems, analysis of narrow band systems.

8. **Non Linear Vibrations:**
   - Systems with non-linear elastic properties, free vibrations of system with non-linear elasticity and damping, phase-plane technique, Duffing’s equation, jump phenomenon, Limit cycle, perturbation method.
8. Noise and Its Measurement :-


Term Work

Any Three from Sr. No 1 to 5 & Sr. No 6 Compulsory

1. Determination of Natural Frequencies & Modal analysis of Machine Components, Equipment to be used: FFT Analyzer, with Impact Hammer or Exciter, Necessary Transducers etc.
2. Condition Monitoring & Fault finding of Machines by using FFT Analyzer, Vibration Meter, Vibration Pickups, Transducers etc.
3. Noise measurement & Analysis, Equipment to be used: Noise measurement & analysis Instruments.
4. In-situ (on-Line) balancing of rotors.
5. Problems of Numerical Methods of Vibrations.
6. Assignment on solving vibration problems using MATLAB.

Reference Books

1. **Theory of Vibrations with Applications**: W T Thomson CBS Publishers Delhi
2. **Mechanical Vibrations**: S S Rao Addison-Wesley Publishing Co.
5. **Mechanical Vibrations**: A H Church, John Wiley & Sons Inc
7. **Mechanical Vibration Analysis**: Srinivasan, McGraw Hill.
8. **Mechanical Vibrations**: G K Groover.
Advanced Machine Design  
(502209)

Teaching Scheme
Lectures: 3 Hrs per week

Examination Scheme:
Paper: 100 Marks
Paper Duration: 3 Hrs.

1. **Engineering statistics**: -
   Analysis of variance (ANOVA), factorial design and regression analysis. Reliability theory, design for reliability, Hazard analysis, fault tree analysis

2. **Fatigue and Creep**: -
   Introduction, Fatigue strength, factors affecting fatigue behaviour, Influence of super imposed static stress, Cumulative fatigue damage, fatigue under complex stresses, Fatigue strength after over stresses, True stress and true strength, mechanism of creep of material at high temperature, Exponential creep law, hyperbolic sine creep law, stress relaxation, bending etc

3. **Optimization**: -
   Introduction, multivariable search methods, linear & geometric programming, structural and shape optimization and simplex method.

4. **Composite materials**: -
   Composite materials and structures, classical lamination theory, elastic stress analysis of composite material, Fatigue strength improvement techniques, stresses, stress concentration around cutouts in composite laminates, stability of composite laminate plates and shells, Hybrid materials, applications.

5. **Design for Materials and Process**: -
   Design for brittle fracture, Design for fatigue failure, Design for different machining process, assembly & safety etc.

6. **Design of Mechanical components**:
   a) **Gear Design**: - Involute gears, tooth thickness, interference, undercutting, rack-shift etc. Profile modification, S and So spur, helical gears etc.

   b) **Spring Design**: - Vibration and surging of helical springs, helical springs for maximum space efficiency, analysis of Belleville springs, ring spring, volute spring & rubber springs. Design for spring suspension.

   c) **Design of Miscellaneous components (to be detailed)** Cam shaft with valve opening mechanism, piston, cylinder, connecting rod etc.
LAB PRACTICE
   1  One complete design project considering all above concepts
   2  Two assignments (Gear & spring)

REFERENCE BOOKS
   1. Mechanical Design Analysis –  M.F. Spotts
   3. Practical Gear design -        D.W. Dudley
   4. Optimum design -              R.C.Jhonson
Analysis and Synthesis of Mechanisms
(502210)

Teaching Scheme
Lectures: 3 Hrs per week

Examination Scheme:
Paper: 100 Marks
Paper Duration: 3 Hrs.

1. Basic Concepts: Definitions and assumptions, planar and spatial mechanisms, kinematic pairs, degree of freedom

2. Kinematic Analysis Of Complex Mechanisms: velocity-acceleration analysis of complex mechanisms by the normal acceleration and auxiliary point methods.


4. Curvature theory: Fixed and moving centrodes, inflection circle, Euler- Savy equation, Bobillier constructions, cubic of stationary curvature, Ball’s point, Applications in dwell Mechanisms

5. Graphical Synthesis of Planar Mechanisms: Type, number and dimensional synthesis, function generation, path generation and rigid body guidance problems, accuracy (precision) points, Chebychev Spacing, types of errors, Graphical synthesis for function generation and rigid body guidance with two, three and four accuracy points using pole method, center point and circle point curves, Bermester points, Synthesis for five accuracy points, Branch and order defects, Synthesis for path generation.

6. Analytical synthesis of Planar Mechanisms:- Analytical synthesis of four-bar and slider- crank mechanism, Freudenstein’s equation, synthesis for four accuracy points, compatibility condition, synthesis of four-bar for prescribed angular velocities and accelerations using complex numbers. Complex numbers method of synthesis, the dyad, center point and circle point circles, ground pivot specifications, three accuracy point synthesis using dyad Method, Robert Chebychev theorem, Cognates


References:

Term Work:
The term work comprises of assignments on the following topics.
1. Complex Mechanism Analysis.
2. Dynamic Analysis.
Use of softwares such as 'ADAMS' and 'Working Model' is recommended.
Reliability Engineering (Elective-III)
(502211-A)

Teaching Scheme
Lectures: 3 Hrs per week

Examination Scheme:
Paper: 100 Marks
Paper Duration: 3 Hrs.

1) **Fundamental concepts:-**
   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,

2) **Probability theory:-**
   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.

3) **System reliability and modelling:**

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

5) **System reliability Analysis:**
   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.

6) **Strength based reliability:**
   Safety factor, safety margin, Stress strength interaction,

7) **Failure Mode, Effects and Criticality Analysis:**
   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, Fault tree analysis, fault tree evaluation techniques, minimal cut set method, Delphi methods, Monte carlo evaluation.

8) **Design of Mechanical components and systems:-**
Material strengths and loads, Reliability testing and reliability growth testing.

**Reference Books**

Review of - Mechanical properties of solid materials, Theory of elasticity Stress and strain, plane stress, plane strain, stress function, Theory of plasticity, yield stress, yield conditions (Mises & Tresca)

1. Introduction:-
Macroscopic failure mode, ideal fracture strength, energy release rate, Fracture Modes.

2. Fracture Criteria :-
Griffith criterion, Irwin’s Fracture Criterion, Stress Intensity Approach, Stress intensity factor, crack tip plasticity, crack opening displacement, plastic constraint.

3. Methods for Evaluating Fracture toughness :-
   3.1 - Numerical Methods
      a. Finite Elements (FE)
      b. Finite Differences (FD)
      c. Boundary Integral Equations (BIE)

   3.2. Experimental Methods
      a. Compliance Method
      b. Photoelasticity
      c. Interferometry and Holography

4. Experimental evaluation of Fracture toughness:- Plane strain fracture toughness, J – Integral


Special Note: – No question should be asked on review topic, derivations.

References :-

3. ASTM standards
1. Introduction:–
   a) Modeling and simulation as a design procedure and be able to apply this method to a wide range of problems.
   b) Analytical techniques for structural systems, system dynamics and thermo-fluid systems.
   c) Introduction to geometric modeling technology and associated computational geometry. A study of data exchange issues related to analysis and simulation.

2. Computer aided Modeling:–
   Modern features-based modeling system for the purposes of designing an assembly and use this geometry as the basis for analysis and simulation, utilizing available data-exchange mechanisms.

3. Finite Element Analysis:–
   Mechanical design criteria - Function, strength and cost. Introduction to FEM Software – meshing, mesh refinement, apply loads and constrains, assign material properties A machine component design exercise - use FEA software to determine dimensions and materials for all parts, modify, optimize and verify the design Numerical result analysis and assessment - von Misses stress, displacement.

4. Computer aided Designing:–
   Design of components and systems for stress analysis and heat transfer using fully featured commercial finite element software having linear & non-linear capabilities. (To be assessed through various course works). Verification of results for the component analyzed, with appropriate hand calculations.

5. Computational Fluid Dynamics:–
   Form of mass, energy and momentum equations, description of terms; boundary conditions and simple solution examples. Features of CFD Modeling for steady incompressible flow, pressure drop and heat transfer. Solution Methods - Solution algorithms, discritization schemes, solution convergence, and residuals. Model Formulation - Geometry and grid design, boundary conditions of the domain, choice of physical models for turbulence and heat transfer, modeling of fluid properties. Case Study Examples - Modeling pressure drop and heat transfer in a range of engineering examples.

Note:– No numerical, derivations & computer programs should be asked in theory examination.
Term work :-
1. Solid Modeling & Assembly modeling in CAE Software.
2. Engineering problem solving using FEA Software applied to a range of practical and industrially relevant stress analysis and heat transfer problems.
4. An insight into the analysis and simulation of plastic and composite components.

Reference Books
1. CAD/CAM Theory & Practice, Zeid, TMH
3. Introduction to FEM, reddy, J. N., McGrawhill Int.
4. Introduction to FEM, K.J.Bathe, CRC press
Vehicle Dynamics (Elective-IV)  
(502212-A)

Teaching Scheme
Lectures: 3 Hrs per week

Examination Scheme:
Paper: 100 Marks
Paper Duration: 3 Hrs.

1. Vehicle Ride

2. Wheeled Vehicle Handling

3. Transient response:
Natural frequency and damping in yaw. Frequency response in yaw. Extension of two degree of freedom theory to include effects of traction and braking, aerodynamics, self-aligning torque, dual wheels and bogies, Handling of multi-axle vehicles. Development of equations of motion to include roll of sprung mass: Effect on steady state and frequency response.

4 Tracked Vehicle Handling
Analysis of sprocket torques and speeds, required to skid steer a tracked vehicle. Extension of theory to include three degrees of freedom. Modification of theory to allow for soil conditions and lateral weight transfer Application of theory of steering of articulated and half-track vehicles.

Texts/References

3. Vehicles & Bridging, igSs/Tytler, Brassey's.
4. Fundamental of vehicle dynamics: Thomas D Gillespie

Industrial Tribology (Elective – IV)  
(502212-B)
Teaching Scheme
Lectures: 3 Hrs per week

Examination Scheme:
Paper: 100 Marks
Paper Duration: 3 Hrs.

Friction and Wear:-
Friction Control and Wear prevention, Boundary Lubrication, Tribological properties of Bearing Materials and Lubricants, Theories of friction and wear, instabilities and stick-slip motion.

Lubrication of Bearings:-
Mechanics of Fluid Flow, Reynold’s Equation and its limitations, idealized bearings, infinitely long plane pivoted and fixed show sliders, infinitely long and infinitely short (narrow) journal bearings, lightly loaded infinitely long journal bearing (Petroff’s solution).

Finite Bearings:-
Hydrostatic, Hydrodynamic and thrust oil bearings, heat in bearings.

Hydrostatic squeeze film:-
Circular and rectangular flat plates, variable and alternating loads, piston pin lubrications, application to journal bearings.

Elasto-hydrodynamic Lubrication:-
Pressure-viscosity term in Reynold’s Equation, Hertz theory, Ertel-Grubin Equation, lubrication of spheres.

Air lubricated bearings:-
Tilting pad bearings, hydrostatic, hydrodynamic and thrust bearings with air lubrication.

Tribological aspects of rolling motion:-
The mechanics of tyre-road interaction, road grip and rolling resistance, Tribological aspects of wheel on rail contact, Tribological aspects of metal rolling, drawing and extrusion.

Tribo characteristics of different materials, Evaluation of friction & wear through experiments under influencing parameters, \( pV \) value of materials.

Term Work
Assignments –
Design of acoustic thrust bearings, Squeeze film lubrication of piston pin, Heat balance in bearings, Reynold’s Equation
**Practicals on:-**

Journal Bearing Apparatus
Tilting pad and thrust Bearing Apparatus
Study of lubrication systems.
Friction in Journal Bearings.
Four Ball Tester
Coefficient of friction using pin on disc type friction monitor.
Brake line friction test rig.

Reference Books –

1. Basic Lubrication Theory- A Camaron
4. Fundamental of Friction and Wear of Metals – ASM
5. The Design of Aerostatic Bearings – J. W. Powell
6. Gas Bearings – Grassam and Powell
7. Theory Hydrodynamic Lubrication Pinkush and Sterrolicht
8. Tribology in Machine Design – T. A. Stolarski