GUJARAT TECHNOLOGICAL UNIVERSITY

M.E

(Mechanical) Machine Design

THEORY OF ELASTICITY

Component of stress and strain, their Principal values and invariants. Generalized Hook's Law. General 3-D problems and classical theorems. Plane stress and plane strain. Stress functions; Applications; Complex potentials in two dimensional and axisymmetric problems; Variational methods; Anisotropic elasticity; Thermoelasticity, Finite deformation elasticity.

References:

1. S.P. Timoshenko and J.N. Goodier, Theory of Elasticity, McGraw –Hill
2. Mohammed Amin, Computational Elasticity, Narosa Publishing House
3. L. S. Shrinath, Advanced Mechanics of Solids, TMH

Dynamics of Machinery

Vibrations: Review of lumped parameter modeling of vibrations, vibrations of continuous systems – bars, beams and plates; Flexural and torsional vibrations, classical and approximate methods of vibration analysis. Vibration isolation of single degree and multidegree freedom systems.

Automatic Control: Control systems, concepts of feed back control; Types of control actions. Effect on control system's performance, state – variable characterization of dynamic systems, Transient and frequency response, stability, Routh and Nyquiest criteria, Root locus method, Application to process and machine tool control; Adaptive control.

Cam Dynamics: Forces in rigid systems, Mathematical models, Response of a uniform motion undamped cam mechanism, Analytical method, Position error, Follower response by phase plane method, Jump and cross over shock, Johnson's numerical analysis, Unstable spring surge and wind up.

Noise Engineering: Fundamentals of sound; Normal Modal Harmonic Analysis, Random aspects of noise; Spectral density; Auto correlation function and their properties; Noise measurement and control.

References:

1. Vibration Problems in Engineering by S. Timoshenko - Wiley Estern
2. Shock and Vibration Handbook by C.M. Harris and C.E. Grede (Ed.) - McGraw Hill
3. Noise and Vibration Control by Leo L. Bernack - McGraw Hill
4. Theory of Vibration and Applications by Thomson W.T. - Prentice Hall

Engineering Optimization

Introduction
Classical optimization methods: Introduction, Review of single and multi variables optimization techniques with and with out constraints.
Unconstrained optimization techniques: Direct search, Fibonnacci, Golden section, Quadratic interpolation, and Newton methods; Univariate, pattern search, steepest decent methods and variable metric method
Constrained optimization techniques: Cutting plane method, method of feasible directions, exterior and interior penalty function methods
Geometric Programming
Recent developments: GA, ANN, simulated annealing

References:

1. Optimization Theory & Applications by S.S. Rao - Wiley Estern
2. Optimization Methods for Engineering Design by R.L. Fox - Addison Wesley
3. Applied Optimal Design, E J Haug, J S Arora, Wiley
4. Optimization, G V Reklaites, A Ravindren, K M Rogsdeth, Wiley

Geometric Dimensioning and Tolerancing

Introduction: Geometric Dimensioning and Tolerancing, Maximum Material Condition, and Regardless of Feature Size
How to read a Feature Control Frame
Size Control Form: Rules, concepts, Characteristics, and Untoleranced Dimensions
Datums, The Maximum Material Condition symbol and its Ramifications, Relationship between Individual Feature's; Virtual Condition and Resultant condition Boundaries; Datum Feature of Size Representation; Form Controls; Orientation Controls; Profile; Run out; Location
A Logical Approach to part Tolerancing, Dimensioning and Tolerancing Schemes, Steps for the Development of a Dimensional Inspection Plan
Paper Gauging; Functional Gauging

References:

1. James D Meadows, Geometric Dimensioning and Tolerancing, Marcel Dekker, Inc
2. James D Meadows, Measurement of Geometric Tolerancces in Manufacturing

MACHINE TOOL DESIGN

Manufacturing system approach in the Design of Machine Tools, Kinematics & dynamics of Machine Tools

Design of slides and slide ways, spindles, bearings, columns, etc. stiffness and rigidly

Design of mechanical, electrical and hydraulic drives, protective and safety devices

Selective and pre-selective mechanisms

Concepts of aesthetics and ergonomics in Machine Tools

Recent Development in the design of Machine tool elements

References:

1. Design Principles of Metal Cutting Machine Tools by F. Koenigsberger - Macmillan
2. Principles of Machine Tools by G.C. Sen and A. Bhattacharya - New Central Book Agency
3. Design of Machine Tools by S.K. Basu and D.K. Pal - Oxford & IBH
4. Machine Tool Design by N.K. Mehta - Tata MacGraw Hill
5. Machine Tool Design (Vol. 3 & 4) by N. Acherkan - Mir Publishers

Mechanical Vibration and Diagnostics

Review of Single degree of freedom systems: systems with more than one deg ree of freedom.
Continuous systems
Transient Vibrations, self excited vibrations, elementary random and nonlinear vibrations
Vibration measuring instruments
Electromechanical Analysis
Applications to Machine Tools, Foundations, etc

References:

1. G.K. Grover, Mechanical Vibrations, Nemchand & Bros, Roorkee -1996.
2. S. Graham Kelley, Fundamental of Mechanical Vibrations, McGraw Hill international, 1993.
3. W.I. Thomson, Theory of Vibration with Application Prentice Hall, 1975.
4. R.A. Anderson, Fundamentals of Vibration, Amerind Pub Co., 1972.
5. S.S. Rao, Mechanical Vibrations, Addison - Wesley Pub. Co., 1995.

Fracture Mechanics

Introduction to linear Elastic Fracture Mechanics. Elasto-Plastic fracture mechanics. Dynamic and Comutational fracture. fracture of composite materials. Damage mechanics and experimental analysis.

References:

1. D. Brock, Elementary Engineering Fracture Mechanica, Noordhoff
2. S T Rolfe, J M Barson, Fracture, and Fatigue Control in structurers, Prentice Hall
3. A P Parker, The Mechanics of Fracture and Fatigue, an Inroduction, E& F N Shon Ltd.

Computer Aided Design

Introduction: Product cycle and CAD; CAD Hardware; Display devices, Input/Output devices, Display processors, Hardware integration and networking; CAD Software

Computer Graphics: windowing and clipping algorithms, Bresenham's circle and ellipse generating algorithms

Curves and Surfaces: parametric representation of analytic and synthetic curves, curve manipulation techniques, parametric representation of analytic and synthetic surfaces, surface manipulation techniques

3D Modelling: Primitives; wire frame, boundary and solid models; constructive solid Geometry (CSG); applications

Database Techniques: Data structure, Database management, Graphics standards, Graphics database design, user interface.

Design and Analysis: Parametric design and programming. Animation and simulation, Mathematical modeling and methods of solution.

References:

1. CAD in Mechanical Engineering by V. Ramamurti - Tata McGraw Hill
2. Mathematical Elements for Computer Graphics by Rogers D.F. - McGraw Hill
3. Principles of CAD by J. Flooney and P. Steadman - Affiliated East West Press
4. CAD/CAM Theory & Practice by Ibrahim Zeid - McGraw Hill
5. Procedural Elements for Computer Graphics by Rogers and Adams - McGraw Hill

Product Design

Introduction to product development
Product development process tools: Product development teams and planning
Scoping Product development: Determining what to develop, Mission statement and Technical questioning, Business case analysis, Design drivers
Understanding Consumer Needs: Customer satisfaction, gathering customer needs, organizing and prioritizing customer needs
Establishing Product needs: Functional development, function trees, establishing system functionality, Augmentation, functional common basis
Product Tear down and Experimentation: Tear down process, methods and application.
Benchmarking and Establishing Engineering Specification: Benchmarking approach, Support tools for Benchmarking, Setting product specification
Product Architecture: Product Modularity, Modular design by clustering and functional methods
Generating Concepts: Basic methods and advanced methods
Concept Selection; Estimating Technical Feasibility, Concept selection processes, basic and advanced methods; Concept Embodiment; Modelling of Product Metrics

References:

1. Kevin Otto, Kristin Wood, Product Design – Techniques in Reverse Engineering and New product Development
2. Eary and Johnson, Process Engineering
3. George E Dieter, Engineering Design, McGrawhill int. Edition
4. Chitle, Product Design, PHI

DESIGN FOR MANUFACTURE

Concepts of Design for manufacture; Relating product requirements with capabilities and limitations of processes of manufacture like casting, forging, rolling, extrusion, sheet metal forming, shearing and machining. Computer aided process oriented design for manufacturing of castings, forgings process tool components, machined components and tooling.

References:

1. Fundamentals of Process Engineering by V. Kovan - Foreign Languages Publishing House
2. Handbook of Product Design for Manufacturing by J.G. Bralla - McGraw Hill

DESIGN OF MATERIAL HANDLING EQUIPMENT

Objectives of material handling systems; basic principles, classification and selection of material handling equipment, Characteristics and applications, parameters affecting service; Packaging and storage of materials and their relation with material handling; Design of various component parts of material handling systems.

Kinematic and dynamic analysis of various types of cranes and elevators; stability and structural analysis, fault finding and failure analysis, system design and economics.

References:

1. Materials Handling Equipments by N. Rudenko - Peace Publishers
2. Conveyors and Related Equipments by Spivakowsky - Peace Publishers
3. Conveying Machines by Spivakowsky and V. Dyachke - MIR Publishers
4. Belt Conveyors for Bulk Materials (2^{nd} Ed) by Conveyor Equipment Manufacturers Association

GEAR DESIGN

Principles of gear tooth action, gear geometry
Analysis and design of spur, helical, bevel and worm gearing, working stresses, bearing loads, shear stresses and power losses in gear drives
Modes of gear failure and remedial measures
Gear materials, gear lubrication, design of gear boxes, special applications of gears

References:

1. Fundamentals of Gear Design by Raymond J. Drago - Butterworths
2. Handbook of Gear Design by G.M. Maitra - Tata McGraw Hill
3. Gear Design Handbook by W.A. Tuplin - Machinery
4. Gear Handbook by D.W. Dudley - McGraw Hill

Tribology

Metrology of surfaces, nature of friction and wear processes
Materials for wear reduction and control; coatings for wear resistance
Theory, testing and control of corrosion, Lubricants and bearing materials
Hydrodynamic lubrication, Steady state and dynamically loaded bearing design, Elasto hydrodynamic lubrication, rolling element bearing and gear lubrications, Hydrostatic lubrication, Lubrication problems at certain extreme environmental conditions e.g. pressure, temperature and vacuum
Analysis and design of variable speed drive elements.

References:

1. Friction Wear Lubrication: Tribology Handbook Vol. I, II and III by I.V. Kragelsky and V.V. Alisin - MIR Publishers
2. Basic Lubrication Theory by A. Cameron, C.M. Mc. Ettles - Wiley Eastern
3. Fundamentals of Tribology by N.P. Suh and N. Saka - MIT Press
4. Theory & Practice of Lubrication for Engineers by D.D. Fuller - John Wiley

Finite Element Methods

Introduction
Introduction to the Stiffness Method: Stiffness matrix for spring element, direct stiffness method, boundary conditions
Development of Truss Equations: Stiffness matrix for bar element, approximation function for displacement, global stiffness matrix, solution of a plane truss, potential energy approach
Development of beam Equations: beam stiffness, distributed loading, potential energy approach
Frame and Grid Equations: 2-D arbitrarily oriented element, skewed supports, grid equations, beam element arbitrarily oriented in space, concept of sub-structure analysis
Development of Plane stress and Plane strain Stiffness Equations: Basic concepts of Plane stress and Plane strain, constant-strain triangular element, constant-strain triangular stiffness matrix, plane stress problem
Development of the Linear-Strain Triangle Equations; Axisymmetric Elements; Isoparametric formulation; Three-Dimensional stress analysis; Plate bending element

References:

1 Daryl L. Logan, A First Course in the Finite Element Method, Thomson
2 R D Cook, D S Malcus, M E Plesha, Concepts and applications of Finite Element Methods
3 Chandrupatla and Belegundu, Introduction to Finite Elements in Engineering

ROBUST DESIGN

Introduction of Quality Engineering; Analysis of Quality Information and Quality Improvement Effort
Fundamentals of Designing Experiments: Orthogonal Array Experiments, Parameter Design for Continuous Data, Parameter Design for Discrete Data, Alternative Parameter Design and Other Considerations, Parameter Design for Dynamic Characteristics, Tolerance Design
Robust Response Surface Design and Analysis
Six Sigma for Management Innovation
Further Issues for the Implementation of Six Sigma
Design for Six Sigma
Robust Design and Implementation of Six Sigma

References:

1. Sung H Park, Jiju Antony, Robust Design For Quality Engineering And Six Sigma
2. John Lawson, John Erjavee, Modern Statistics for Engineering and Quality Improvement,Thomson
3. Philip Ross, Taguchi Techniques for Quality Engineering, McGrawhill

ROBOTICS

Introduction: Robot anatomy, classification of robots, work envelope

Systems Review: Drives, control, sensors and end effectors, gripper actuators and gripper design
Co-ordinate Systems: Robot coordinate system representations, transformations
Manipulator Kinematics: Parameters of links and joints, kinematic chains, dynamic of kinematic chains, trajectory planning and control, advance techniques, parallel actuated and closed loop manipulators
Robot Motions & Motion Control: Differential equations, transform method, control system, position sensing, velocity sensing
Robot Programming and Application
Robot economics, safety and integration

References:

1. Rototics by K.S. Fu, R.C. Gonzalez, C.S.G. Lee - McGraw Hill
2. Rototics for Engineers by Y. Koren - McGraw Hill
3. Industrial Robotics by M.P. Groover - McGraw Hill
4. Robot Engineering: An Integrated Approach by Klafter et. Al. - P.H.I.
5. Robotics, J J Craig, Addison

Reliability Engineering

Introduction to Reliability Engineering; Reliability Mathematics; Load-strength Interference
Statistical Experiments: Statistical Design of experiments and ANOVA
Reliability prediction and Modelling: system reliability models, Modular design, Fault Tree Analysis, Petri Nets, Markov Analysis, Monto Carlo Simulation
Reliability in Design: Quality Function Development, Load-strength analysis, Failure modes, effects and criticality analysis (FMCEA), Reliability prediction for FMCEA; Reliability of Mechanical Components and System: Mechanical stress, strength, fracture, fatigue, creep, wear, corrosion, vibration and shock, temperature effects, materials, components, processes.
Reliability Testing: Planning reliability testing, Test environments, testing for reliability and durability: accelerated test, failure reporting, analysis and corrective action systems.
Analysis of Reliability Data: Pareto analysis, accelerated test data analysis, reliability analysis of repairable systems, reliability demonstration, Non-parametric methods, reliability growth monitoring.

References:

1. Patrick D. T. O'Connor, Practical Reliability Engineering, John Wiley & Sons
2. L S Srinath, Concepts in Reliability Engineering, Affiliated East West Publishers

Optimization Techniques

Single and Multivariable optimization methods, constrained optimization methods, Kuhn –Tucker conditions-Necessary & sufficiency theorems.
Linear programming-Traveling salesman problem and Transshipment problems -post optimization analysis. Integer programming-All integer, Mixed integer and zero -one programming. Geometric programming - concept - degree of difficulty - solution of unconstrained & constrained non linear problems by geometric programming.
Dynamic programming.

REFERENCES :

1. K. Deb, "Optimization for Engineering Design", Prentice Hall of India, 1995.
2. S.S. Roa, "Optimization Theory And Application", Wiley Easter, 198 4.
3. Reklaitis G.V., Ravindram A., Ragsdell K.M., "Engineering Optimization - Methods & Application", Wiley, 1983.

QUALITY CONTROL & RELIABILITY

Concepts in Quality Management
Quality planning, quality measurement, quality assurance, troubleshooting, diagnostic techniques, quality costs, systems approach in quality management, TQM, Taguchi concept, ISO 9000.

Control Charts: Shewhrt, Cusum, SSR; economic design of control charts.
Industrial Applications of Experiment Design and Analysis in Troubleshooting
Quality Assurance through Acceptance Sampling
Single, double, multiple sequential sampling of lots, continuous sampling plans.
Economic design of quality assurance plans in single and multi stage production.

Quality in the form of reliability, reliability assurance tests design, analysis of fault trees for system failure, cause effect diagrams, quality control circles.
Evolutionary Operation and Response Surface Methodology
Statistical analysis of life time data. Analysis of semi-Markov processes and regenerative phenomena in determination of systems availability and reliability.

REFERENCES :

(i) Quality Control Hand Book by J.M. Juran et. Al. - McGraw Hill
(ii) Statistical Quality Control by E.L. Grant and R.S. Levernworth - McGraw Hill – Koga Kusha
(iii) Hand Book of Industrial Engineering and Management by W.G. Ireson and E.L. Grant - Prentice Hall
(iv) Quality Control and Applications by B. Hansen and P.M. Ghare - Prentice Hall