Department of Mechanical Engineering

Curriculum & Brief Syllabi for M.Tech. in Machine Design

Curriculum

First Semester

Code	Title of the course	L	T	P/S	C
MA6001	Mathematical Methods	3	-	-	3
ME6601	Advanced Mechanics of Solids	3	-	-	3
ME6602	Theory of Vibrations	3	-	-	3
ME6330	Industrial Tribology	3	-	-	3
	Elective - I	3	-	-	3
	Elective - II	3	-	-	3
ME6691	Design Engineering Laboratory	-	-	3	1
ME6692	Seminar	-	-	3	1
	Total	**20**			

Second Semester

Code	Title of the course	L	T	P/S	C
ME6611	Advanced Mechanisms	3	-	-	3
ME6612	Materials Selection in Mechanical Design	3	-	-	3
ME6613	Advanced Methods in Engineering Design	3	-	-	3
ME6325	Finite Element Methods and Applications	3	-	-	3
	Elective -III	3	-	-	3
	Elective -IV	3	-	-	3
ME6693	CAD Laboratory	-	-	3	1
ME6694	Term Paper/ Mini Project/ Industrial Training	-	-	3	1
	Total	**20**			

Third Semester

Code	Title of the course	L	T	P/S	C
ME6695	Project work	-	-	-	8
	Total	**8**			

Fourth Semester

Code	Title of the course	L	T	P/S	C
ME6696	Project work	-	-	-	12
	Total	**12**			

Total credits : 60

Stipulations

1. A minimum of 60 credits have to be earned for the award of M.Tech. Degree in this programme.
2. Students have to credit a minimum of eight core courses and four electives during the programme; however they have option to credit two electives in third semester, drawing one each from first and second semesters.
3. Students may undergo Industrial Training during May-June

List of Electives

Sl. No.	Code	Title	Credits
1	ME6322	Computer Graphics	3
2	ME6511	Composite Materials: Mechanics, Manufacturing and Design	3
3	ME6633	Optimization Techniques	3
4	EE6129	Artificial Neural Networks and Fuzzy Systems	3
5	ME6329	Design of Experiments	3
6	ME6323	Six Sigma	3
7	ME6621	Analytical & Computational Mechanics	3
8	ME6622	Non-linear Dynamics & Chaos	3
9	ME6623	Fracture Mechanics and Fatigue	3
10	ME6624	Advanced Materials	3
11	ME6625	Rotor Dynamics	3
12	ME6626	Theory of Plasticity	3
13	ME6627	Robotics	3
14	ME6628	Design of Electro-Mechanical Systems	3
15	ME6629	Dynamics of Continuous Systems	3
16	ME6630	Computer Aided Mechanical Design	3
17	ME6334	Experimental Stress Analysis	3
18	ME6631	Machine Tools Design and Analysis	3
19	ME6632	Control Systems engineering	3

***Note**: Students may choose any course offered in the Institute with the approval from the Programme Coordinator*

Brief Syllabi

FIRST SEMESTER

MA6001 Mathematical Methods

Special functions and series solution of ODEs, Legendre polynomials and Bessel functions, Abstract vector space, Linear dependence and independence of vectors, Linear transformation and matrices, Eigen values and eigen vectors of linear operator, Introduction to integral equations, Review of Tensor analysis.

References:

1. F.G. Flory, *Elementary Linear Algebra with Application*, Prentice Englewood
2. D.C. Lay*, Linear Algebra and its Applications*, Addison Wesley, 2000
3. W.W. Bell*, Special Functions for Scientists and Engineers*, van Nostrand
4. B. Spain, *Tensor Calculus*, Oliver and Boyd
5. J. Irving and N. Mullineux, *Mathematics in Physics and Engineering*, Academic Press, 1957
6. F.B. Hildebrand, *Methods of Applied Mathematics*, Prentice Hall
7. A.C. Bajpai, L.R. Mustoe and D. Walker: Advanced Engineering Mathematics, John Wiley, 1978
8. L.A. Pipes and L.R. Harwill, *Applied Mathematics for Engineers and Physicists*, McGraw Hill, 1970.

ME6601 Advanced Mechanics of Solids

Theory of stresses and strains, Introduction of tensors, Constitutive modeling, Linear elasticity, Solutions of plane problems, Solutions using polynomials, Energy methods, Introduction to finite deformation, plasticity, stability, vibration and wave propagation.
Application to thick cylinders, rotating discs, curved beams, beams on elastic foundations, torsion of non-circular cross-sections, stress concentration problems, Hertzian contact stresses.
Theories of failure, Static failure theories, Fatigue failure theories, Case studies, Design for fatigue

References:

1. Durelli, Philips and Tsao, *Introduction to the Theoretical and Experimental Analysis of Stress and Strain,* McGraw Hill; New York.
2. Timoshenko S and Goodier J N, T*heory of Elasticity*, McGraw Hill, 1970.
3. Fung Y.C., *Foundations of Solid Mechanics*, Prentice Hall of India, 1968.
4. Boresi A.P. Schmidt R J and Sidebottom O M, *Advanced Mechanics of Materials*, John Wiley, 1993.
5. Fenner R T, *Engineering Elasticity Application of Numerical and Analysis Techniques*, Ellis Hordwood Ltd 1986.

ME6602 Theory of Vibrations

Introduction: Single degree of freedom systems: Free and forced vibration, Damping concepts, Vibration isolation, Impulse response and frequency response functions, Transducers.
Two degree of freedom systems: Free and forced vibration, Vibration absorber design.
Multi degree of freedom systems: Matrix formulation of Eigen value problem and solution techniques, Mode superposition principle for forced response, Component mode synthesis, Engineering case studies.
Continuous systems: Strings; bending, torsonal and axial vibration of beams.

References:

1. W.T. Thomson, *Theory of Vibration with Applications*, Prentice hall of India, New Delhi, 2003
2. L. Meirovitch, *Elements of Vibration Analysis*, McGraw-Hill, 1986
3. J. P. Den Hartog, *Mechanical Vibrations*, McGraw-Hill

ME6330 Industrial Tribology

Basic equations, Navier-Stokes equations, Reynolds equation and energy equation, Mechanism of pressure development, Finite bearings, instability, design and analysis of bearings, wear, surface topography and measurement, theories of friction, Fatigue and impact wear, wear of metals and non-metals.

References:

1. B.C Majumdar*, Introduction to Tribology*, A H Wheeler, Bangalore
2. Pinkus and Sternlicht, *Theory of Hydrodynamic Lubrication*, John Wiley & Son, New York
3. D F Moore, *Principle and Application of Tribology*, Pergamon Press, New York
4. E Rabinowicz, *Friction and Wear of Metals*, John Wiley & Sons, New York
5. K L Johnson, *Contact Mechanics*, Pergamon Press- Cambridge University Press.
6. T R Thomas, *Rough Surfaces*, Longman Inc.

ME6691 Design Engineering Laboratory

Measurement of friction, wear, stress and strain, stress concentration.
Dynamic response, Measurement of vibration: Free vibration, Forced Vibration.
Calibration of different kinds of Transducers such as LVDT, Load Cells, etc.

ME6692 Seminar

Each student shall prepare a paper on any topic of interest in the field of specialization – Mechanical Systems Design. He/she shall get the paper approved by the Programme Coordinator/Faculty Advisor/Faculty Members in the concerned area of specialization and present it in the class in the presence of Faculty-in-charge of seminar class. Every student shall participate in the seminar. Grade will be awarded on the basis of the student's paper, presentation and his/her participation in the seminar.

SECOND SEMESTER

ME6611 Advanced Mechanisms

Analysis of Planar and Spatial Mechanisms**:** Position analysis of mechanisms, via complex numbers- Newton-Raphson method and programming solutions
Homogeneous transformations - planar, spherical and spatial mechanism, analysis via homogeneous transformations
Path curvature theory
Synthesis of Planar Mechanisms:
Graphical synthesis of planar mechanisms: path generation, function generation and rigid body guidance
Analytical synthesis of planar mechanisms: Freudenstein's equation
Introduction to Multibody Dynamics - Generalised Matrix formulation

References:

1. Parviz E. Nikravesh, *Computer Aided Analysis of Mechanical Systems*, PHI Publications
2. Erdman, A., Sandor, G., and Kota S., Mechanism Design Analysis and Synthesis, Vo. 1, 4 th edition, 2001, Prentice Hall.
3. John Joseph Uicker, *Theory of Machines and Mechanisms*, Oxford University Press
4. Joseph E. Shigley, John J. Uicker, Gordon R. Pennock, G.R. Pennock (Editor) Theory of Machines and Mechanisms, Oxford University Press Inc, USA
5. J.Hannah, R.C.Stephens, E.Arnold, *Mechanics of Machines: Advanced Theory and Examples*, 2nd edition
6. Hartenberg, Richard S., and Denavit, Jacques, Kinematic Synthesis of linkages, McGraw-Hill book company.

ME6612 Material Selection in Mechanical Design

The evolution of engineering materials, Materials and the design process, Functional requirements of engineering materials, Material selection based on properties alone, Material selection based on properties and shape, Processing, materials and design, Materials property data, Latest developments in the use of materials, New materials, Case studies.

References:

1. Charles, J. A., Crane, F. A. A., and Furness, J. A. G., Selection and Use of Engineering Materials, Butterworth-Heinemann, Oxford.
2. Ashby, M. F., Materials Selection in Mechanical Design, Butterworth-Heinemann, Oxford.
3. Ashby, M. F., The Engineers Guide to Materials Selection – Modern Methods and Best Practices, AEA Technology.
4. Watermann, N. A., and Ashby, M. F., (eds), Materials Selection, Chapmann and Hall, 1996.

ME6613 Advanced Methods in Engineering Design

Product Design: Concepts of Product Design, Modeling and simulation, Material selection, Strength and stability considerations, Design for Manufacturability.

Reliability: Definition, Importance of Reliability, Factor of Safety and Reliability, Reliability tests, Reliability techniques, Significance of availability and maintainability concepts.

Failure Analysis: Sources of Failures, Methodology of Failure Analysis, Fractography, Fatigue, Metallography, Corrosion, Polymer Failures, Failure of Ceramics and Glass, Case Studies.

References :

1. Karl T. Ulrich and Steven D. Eppinger, Product Design and Development, McGraw-Hill International Edn., 2004.
2. Benjamin W. Niebel and Alan B. Draper, Product Design and Process Engineering, McGraw Hill Book Co.
3. Dieter, *Engineering Design*, II Edition, McGraw Hill, 1991
4. S.S.Rao, Reliability Based Design, McGraw Hill Inc, New York, 1992.
5. L.S.Srinath, Concepts in Reliability Engineering, Affiliated East West Press Private Limited, New Delhi, 2003.
6. Joseph E Shigley and Charles R Mischeke, Mechanical Engineering Design, TMH Publishers
7. ASM Handbook, Vol. 11, Failure Analysis and Prevention," edited by R.J. Shipley and W.T. Becker, ASM Publications, 2002

ME6325 Finite Element Method and Applications

Basic concepts, variational method, Galerkin's method, shape functions, assembly and solution, scalar and vector field problems, problems in fluid mechanics and heat transfer, elasticity problems, the Euler-Bernoulli beam element, Eigen value and time dependant problems, non-linear problems, error analysis, mesh generation.

References:

1. J. N. Reddy, *An Introduction to the Finite Element Method*, McGraw Hill book company
2. O. C. Zienkiewicz, *The Finite Element Method*, McGraw Hill Book company, New York
3. K. H. Huebner, *The Finite Element Method of Engineers*, John Wily & Sons, New York
4. L. J. Segerlind, *Applied Finite Element Analysis*, John Willy & Sons, New York
5. Cook, R. D., Malkus, D. S., and Plesha, M. E., *Concepts and Applications of Finite Element Analysis*, John Wiley and Sons.

ME6693 CAD Laboratory

Exercises on solid modeling using commercial software packages like Pro-E, CATIA. Exercises on finite element analysis using ABAQUS, ANSYS. Basic exercises on computer aided manufacturing and inspection.

ME6694 Term Paper/ Mini Project/ Industrial Training

Each student shall prepare a paper on any topic of interest in the field of specialization – Machine Design. He/she shall get the paper approved by the Programme Coordinator/Faculty Advisor/Faculty Members in the concerned area of specialization and present it in the class in the presence of Faculty-in-charge of seminar class. Every student shall participate in the seminar. Grade will be awarded on the basis of the student's paper, presentation and his/her participation in the seminar.

Electives

ME6322 Computer Graphics

Overview of computer graphics, representing and interacting with pictures, line drawing and circle generation, Two and three dimensional transformations, Plane curves and parametric curves, splines, Bezier curves , NURBS, Surface description and generation.

References:

1. David F. Rogers and J. H. Adams, *Mathematical Elements of Computer Graphics*, 2nd Edition; McGraw Hill International Editions 1990.
2. David F Rogers, P*rocedural Elements for Computer Graphics*, McGraw Hill International Editions, 1995.
3. Donald Hearn & M Pauline Baker, *Computer Graphics,* Second Edition, Prentice Hall of India Private Limited, 1995
4. Foley, Van Dam Feiner and Hughes, *Computer Graphics Principles and Practice*, Second Edition, Addison – Wesley Publishing Company, 1997
5. Michael E Mortenson, *Geometric Modeling*, John Wiley & Sons, 1985

ME6511 Composite Materials: Mechanics, Manufacturing and Design

Classification and characteristics of composites, analysis of orthotropic lamina, analysis of laminated composites, laminate strength analysis, dynamic analysis of laminate, manufacturing and testing methods, experimental characterization.

References:

1. Gibson, R F., Principles of composite material mechanics, McGraw-Hill
2. B D Agarwal and L J Broutman, *Analysis and Performance of Fiber Composites*, Wiley & Sons, NY, 1990.
3. Jones R M, *Mechanics of Composite Materials*, McGraw-Hill, New York, 1975.
4. David Roylance, Online lecture notes on Composite materials, Department of materials science and Engineering, Massachusetts Institute of Technology, Cambridge
5. D Hull and T W Clyde, *An Introduction to Composite Materials*, 2nd Edition, Cambridge University Press 1996.

ME6633 Optimization Techniques

Mathematical preliminaries, programming problems, difficulties caused by non-linearity, Unrestricted and classical optimization, search methods, sufficiency condition, Constrained non-linear optimization, Problems involving inequality constraints, quadratic programming, method of

feasible solutions, Integer and dynamic programming, tabular and calculus methods, Gomory's cutting plane method, branch and bound methods.

References:

1. N.S.Kambo, *Mathematical Programming Techniques*, Affiliated East West, 1984.
2. M.D.Interiligator, *Mathematical Optimization and Economic Theory*, Prentice Hall, 1971.
3. S.S.Rao, *Optimization Theory and Applications*, Wiley Eastern 1978.
4. D.L.Summons, *Nonlinear Programming for Operations Research*, Prentice Hall 1975.

EE6129 Artificial Neural Networks and Fuzzy Systems

Biological foundations, ANN models, Types of activation function, Introduction to Network architectures: Multi Layer Feed Forward Network (MLFFN), Radial Basis Function Network (RBFN), Recurring Neural Network (RNN). Learning process, Supervised and unsupervised learning. Error-correction learning, Hebbian learning, Boltzmen learning, Single layer and multilayer percepturs, Least mean square algorithm, Back propagation algorithm, Applications in forecasting and pattern recognition and other engineering problems. Fuzzy set operations. Properties, Membership functions, Fuzzy to crisp conversion. fuzzification and defuzzification methods, applications in engineering problems. Fuzzy control systems, simple fuzzy logic controllers with examples, special forms of fuzzy logic models, classical fuzzy control problems . inverter pendulum . image processing. home heating system. Adaptive fuzzy systems, hybrid systems.

References:

1. J.M. Zurada, *Introduction to Artificial Neural Systems*, Jaico Publishers, 1992.
2. Simon Haykins, *Neural Networks: A comprehensive foundation*, Macmillan College, Proc, Con, Inc, New York, 1994.
3. D. Driankov, H. Hellendorn, M. Reinfrank, *Fuzzy Control: An Introduction*, Narosa Publishing House, New Delhi, 1993.
4. H.J. Zimmermann, *Fuzzy Set Theory and its Applications*, III Edition, Kluwer Academic Publishers, London.
5. G.J. Klir, Boyuan, *Fuzzy Sets and Fuzzy Logic*, Prentice Hall of India (P) Ltd., 1997.
6. Stamatios V Kartalopoulos, *Understanding Neural Networks and Fuzzy Logic: Basic Concepts and Applications*, Prentice Hall of India (P) Ltd., New Delhi, 2000.
7. Timothy J. Ross, *Fuzzy Logic with Engineering Applications*, McGraw Hill, New York.
8. Suran Goonatilake, Sukhdev Khebbal (Eds), *Intelligent Hybrid Systems*, John Wiley & Sons, New York, 1995.

ME6329 Design of Experiments

Revision of statistics, descriptive tools, probability plots, inferential statistics, strategies for experimentation, good design requirements, two level factorial experiments, number of replicates, blocking and split plot designs, regression analysis, multiple level factorial experiments, screening designs, response surface methodology, response surface model fitting.

References:

1. Nibtginertm Diygkas C, *Design and Analysis of Experiments*, Fifth Ed, John Wiley & Sons Inc.
2. Box, George E P, Hunter William G, Hunter Sturat J, *Statistics for Experimenters*, John Wiley & Sons Inc.

ME6323 Six Sigma

Design phase, measure phase, probability plotting, six sigma measurements, process performance metrics, confidence intervals, hypothesis tests, comparison tests, analysis of variance, six sigma improve phase, design of experiments, full and fractional factorial DOE, robust DOE, lean six sigma, theory of constraints, design for six sigma, measurement of six sigma.

References:

1. Harry, Mikel and Rich Schroeder, *Six Sigm: The Breakthrough Management Strategy Revolutionizing the World's Top Corporations*, Doubleday, New York, 2000.
2. Montgomery, Douglas C, *Introduction to Statistical Quality Control,* 4th ed., John Wiley & Sons, Inc., New York, 2001

ME6621 Analytical and Computational Mechanics

Kinematics of particles and Rigid bodies - Euler angles, Generalized displacement, position, velocity and acceleration. Rigid body Dynamics - D'Alembert's Principle, Virtual work application in dynamics and Lagrange's equation. Constraints formulation in Multi Body Systems - Formulation of joint constraints for various joints used in practice. Formulations of Constrained Dynamics Equations - Lagrange Multipliers. Multi Body Dynamics Solution - Numerical Integration Application to Vehicle Dynamics, Engine Dynamics, Power Train Dynamics. Tyre models in Vehicle dynamics. Stability Analysis. Deformable Multi Body Dynamic Simulation

References:

1. Ahmed A. Shabana, *Dynamics of Multibody Systems*, 2nd ed., Cambridge university press, 2003
2. Francis C Moon, *Applied Dynamics*, John Wiley and Sons. Inc..1998
3. Wittenberg, *Dynamics of systems of rigid bodies*, Teubner, Stuttgart,1977
4. Greenwood D T, *Principles of Dynamics*, 2nd ed. Prentice Hall, EWnglewood cliffs NJ,1988

ME6622 Nonlinear dynamics and chaos

Introduction to dynamical systems: Discrete time systems-continuous time systems-autonomous and nonautonomous systems-phase space and flows-attracting sets-concepts of stability-fixed point-limit cycle
Local and global bifurcations- static and dynamic bifurcation- bifurcation of maps.
Types of bifurcation- Chaos-period doubling-quasiperiodic and intermittency routs to chaos. Quasiperiodic solutions: Poincare' maps-circle map
Chaotic solutions of maps,Chaotic solutions of continuous systems, period doubling and intermittency mechanisms.
Fractals and dynamical systems: Fractal dimension-measures of fractal dimension-Tools to identify and analyze motions-Fourier spectra- Poincare' sections and maps- Lyapunov exponents.
Computational aspects-Numerical integration-cell mapping-Galerkin-Harmonic balancing-Shooting method-parameter continuation and path following
Applications to mechanical systems-gear with backlash, Clutch springs-bearings, buckled beams etc.

References:

1. Ali H. Nayfeh and B Balachandran, *Applied nonlinear dynamics*, John Wiley & Sons
2. Thomson, J M T and Stewart, H B, *Nonlinear dynamics and chaos*, John Wiley & Sons
3. Francis C.Moon, *Chaotic and Fractal dynamics*, John Wiley & Sons
4. S.H.Strogatz, *Nonlinear dynamics and chaos*, Perseus books publishing, LLC, 2000

ME6623 Fracture Mechanics and Fatigue

Fracture Mechanics: fracture failure modes, linear elastic fracture mechanics – energy approach and stress intensity factor approach, crack tip plasticity, Elasto-plastic fracture mechanics – J-integral and CTOD, advanced topics in fracture, experimental and numerical methods.
Fatigue: Crack nucleation and growth, fatigue life prediction, statistical analysis.

References:

1. Prashant Kumar, *Elements of Fracture Mechanic*s, Wheeler Publishing.
2. Ewalds, H. L., and Wanhill, R. J. H, *Fracture Mechanics*, Edward Arnold Edition.
3. Broek, D., *Elementary Engineering Fracture Mechanics*, Kluwer.
4. Kare Hellan, *Introduction to Fracture Mechanics*, McGraw Hill Book Company.

5. Broek, D., *Practical use of Fracture Mechanics*, Kluwer.
6. Cook, R. D., Malkus, D. S., and Plesha, M. E., *Concepts and Applications of Finite Element Analysis*, John Wiley and Sons.
7. Suresh, S., *Fatigue of Materials*, Cambridge University Press.

ME6624 Advanced Materials

Basics of material science, experimental techniques for metallographic studies, Mechanics of materials behavior, strengthening mechanisms.
Materials for engineering design, Steels, alloy steels, effect of alloying elements on properties of steels, cast irons, non-ferrous alloys, Non-metallic materials; thermoplastics, thermosetting plastics, elastomers, composites, ceramics, glasses.
Recent developments, smart materials, shape memory alloys, functionally graded materials, piezo-electric materials, materials in nanotechnology
Selection of engineering materials for strength, stiffness, toughness, creep, temperature resistance, corrosion resistance and wear resistance, selection for fatigue

References

1. Smith, Science of Engineering Materials, Prentice-Hall
2. Callister W.D., Materials Science and Engineering, John Wiley
3. Charles J.A., Crane F.A.A., Furness J.A.G., Selection and use of engineering materials, Elsevier Publ.
4. Avner S. H., Introduction to Physical Metallurgy, McGraw Hill
5. Van Vlack L. H., Elements of Materials Science, Addison Wesley
6. Shackelford J. F., Materials Science for Engineers, Prentice-Hall
7. Higgins R. A., Engineering Metallurgy *Part I*, Applied Physical Metallurgy, ELBS
8. Raghavan V., Material Science and Engineering, Prentice-Hall of India
9. Reed Hill, Physical Metallurgy Principles, Affiliated East-West Press

ME6625 Rotor Dynamics

Flexural and torsional vibration – discrete equivalent system – torsional vibration in rotating and reciprocating machinery – gyroscopic effects – rotor mounted on bearing – fluid film bearings – instability of rotors – balancing of rotor – condition monitoring – route spectrum.

References:

1. Rao J.S., *Rotor Dynamics*, Third ed., New Age, New Delhi, 1996.
2. Childs D., *Turbomachinery Rotordynamics: Phenomena, Modeling and Analysis*. Research Studies Pub., A Wiley-Interscience Publication, NY, 1993.
3. Darlow M.S., *Balancing of High-Speed Machinery*, Springer-Verlag, 1989.
4. Dimentberg F.M., *Flexural Vibrations of Rotating Shafts*, Butterworths, London, 1961.
5. Dimargonas A.D. and Paipetis S.A., *Analytical Methods in Rotor Dynamics*, Applied Science Publications, London, 1983.
6. Krämer E., *Dynamics of Rotors and Foundations*, Springer-Verlag, New York, 1993.
7. Lee C.-W., *Vibration Analysis of Rotors*, Kluwer Academic Publishers, London, 1993.
8. Mahrenholtz O. (editor), *Dynamics of Rotors; Stability and System Identification*, International Center for Mechanical Science, NY, 1984.
9. Rieger N.F., *Vibrations of Rotating Machinery*, The vibration Institute, Clarendon Hills, Illinois, 1977.
10. Tondl A., *Some Problems of Rotor Dynamics*, Chapman & Hall, London, 1965.
11. Vance J.M., *Rotordynamics of Turbomachinery*, John Wiley & Sons, Inc., NY,1988.

ME6626 Theory of Plasticity

Introduction and fundamentals, yield criteria, stress-space representation, flow rules, principle of maximum work, various applications, theory and applications of slip-line fields and hodographs, steady and unsteady problems in plasticity.

References:

1. Chakrabarty, J., *Theory of plasticity*, McGraw Hill Book Company.
2. Johnson, W. and Mellor, P. B., *Engineering Plasticity*, Van Nostrand Reinhold Company.
3. Prager, W., *Introduction to Plasticity*, Addison Wesley.
4. Lubarda, Vlado A., *Elastoplasticity Theory*, CRC Press.

ME6627 Robotics

Robot Kinematics: Position Analysis: Robot Characteristics**,** Direct Kinematics-DH Representation, Derivation of kinematics equations, Inverse Kinematics **-** Solvability, algebraic vs. geometric, Pipers solution.

Jacobian of Velocities and static forces: Linear and rotational velocity of rigid bodies, velocity propagation from link to link, Tool and Manipulator Jacobian- singularities, static forces in manipulators, Jacobians in force domain, Cartesian transformation of velocities and static forces.

Manipulator Dynamics: Acceleration of a rigid body, mass distribution, Langrangian Mechanics, iterative Newton-Euler dynamic formulation, Langrange-Euler Formulation, Dynamic equations for multiple degrees of freedom Robot.

Trajectory Planning and Control of manipulators: General considerations in path description and generation, joint space schemes, Cartesian space schemes, collision free path planning; Manipulator Control System-Nonlinear and time varying systems, multi-input and multi-output control systems, PID Control Scheme-Force Control of manipulators.

References:

1. John J Craig, *Introduction to Robotics: Mechanics and control*, second edition Addison–Wesley, 1999
2. Saeed B Niku, *Introduction to Robotics: Analysis, Systems and applications*, Prentice Hall India, 2002
3. Mark W Spong & M Vidyasagar, *Robot Dynamics and Control*, John Wiley & Sons, 1989
4. K S Fu R C Gonzales, C S G Lee*, Robotics Control, Sensing, Vision and Intelligence*, McGraw Hill 1987
5. R P Paul, *Robot Manipulators Mathematics Programming, Control*, The computer control of robotic manipulators, The MIT Press 1979
6. Robert J Schilling, *Fundamentals of Robotics, Analysis and Control*, Printice Hall of India 1996
7. R.K.Mittal and I.J.Nagarath, *Robotics and Control*, TMH-2003

ME6628 Design of Electro-Mechanical Systems

Basics solid-state components and devices, elements of electromechanical energy conversion, starting, inversion and control of electrical drives, Coupling of mechanical loads to DC and AC electrical drives and speed control. Optoelectronic encoding, sensing, signal shaping and processing devices and techniques. Basics of digital signal processing data acquisition. Special simulation techniques for mechatronic systems, special techniques for solving of shift system model with switching and delay components. Elements of Telemetry and remote control of mechatronic systems, theory of linear observers, optimal filters and their digital implementations, design and implementation of digital control strategies for mechanical system.

References:

1. Bolton W : *Mechatronics* : Electronic Control Systems in Mechanical and Electrical Engineering; Second Editiion; Addison Wesley Longman Limited; 1999
2. Dan Necsulescu, *Mechatronics***,** Parson Education Asia 2002
3. Modern Control Systems, Richard C. Drof & Robert H Bishop, *Modern Control Systems***,** Addison – Wesley, 1998
4. Krishna Kant; *Computer Based Industrial Control* **;** Prentice Hall of India Pvt. Ltd. 1999.
5. HMT Limited; *Mechatronics***:** Tata McGraw-Hill Publishing Company Limited 1998
6. Herbert Taub & Donald Schilling : *Digital Integrated Electronics*, McGraw Hill International Edition, 1977

ME6629 Dynamics of Continuous Systems

Basic concepts of vibration, Distributed parameter systems, Vibration of strings, rods shafts and beams, Differential Eigen Value Problems, Vibration of membranes, undamped damped and gyroscopic systems, Approximate methods, State-space formulation.

References:

1. Leonard Merovich, *Principles and Techniques of Vibrations*, , Prentice Hall International, 1997.
2. Leonard Meirovich, *Elements of Vibration Analysis,* , International Student Edition, Prentice Hall International, 1975.
3. W.T. Thomson *, Theory of Vibration with Applications,* , Prentice Hall International, 1990.
4. J.P. Den Hartog, *Mechanical Vibrations,* , Mc Graw- Hill Book Company, 1947.
5. J. N. Reddy, *An Introduction to Finite Element Method,* , McGraw Hill International, Second Edition, 1993.

ME6630 Computer Aided Mechanical Design

Introduction - Finite element procedure, Typical elements, Pre and post processing, Finite difference method, General approach, Matrix inversion, Gaussian elimination method, Choleskey method, Variable bandwidth, bandwidth reduction. Wave front technique, Industrial applications, case studies. Eigen value problems - Definition, Properties of eigen values, Typical problem formulation, Different numerical methods, Industrial applications, case studies Cyclic symmetric structure - Static analysis under symmetric loading, static analysis under generalized loading, Eigen value problem. Industrial applications, case studies Dynamic analysis - Quasi static methods, Direct integration method, Mode superposition, condition for stability, Random vibration modeling, Case studies

References:

1. Ramamurthi, V., *Computer Aided Mechanical Design and Analysis*, Tata McGraw Hill Publishing Company Limited, New Delhi.
2. Krishnamoorthy, C. S., *Finite Element Procedure-Theory and Programming*, TMH Publications
3. Desai, C. S., *Introduction to finite element analysis, A Numerical Method for Engineering Analysis*
4. Hovanassian, S. A, L.A. Pipes, *Digital Computer Methods in Engineering*, McGraw-Hill Publications
5. Salvadori, M.G, Baron, M. L., *Numerical Methods in Engineering*, PHI Publications
6. Meirovitch, L., *Computational Methods in Structural Dynamics*, Sijthoff and Noordhoff, Rockwille, USA
7. Kramer, E., *Dynamics of Rotor and Foundations*, Springer-Verlag, Berlin
8. Bullouin, L., *Wave Propagation in Periodic Structures*, Dover publications
9. Wilson W, *Practical Solution for Torsional Problems*, Chapman and Hall Publications
10. Thomson, W. T., *Theory of Vibrations with Applications*, PHI Publications

ME6334 Experimental Stress Analysis

Theory of stresses and strains review.
Basic concepts in measurement - Measurement of displacement, strain pressure, force, torque etc., - Type of strain gauges (Mechanical, Electrical Resistance, acoustical, etc.,). Electrical resistance strain gauges - Gauge sensitivity and gauge factor - Environmental effects. Strain gauge circuits - The potentiometer and the Wheatstone bridge - Effects of lead wires, switches, etc., - Use of electrical resistance strain gauges in transducer applications. Indicating and recording devices - Static and dynamic data recording - Data (digital and analogue) acquisition and processing systems - Telemetry systems. Strain-analysis methods-Rosette analysis. Static & Dynamic testing techniques - Equipment for loading. Nondestructive testing techniques. Photoelasticity - Optics of photoelasticity - Polariscope - Isoclinics and Isochromatics - Methods of stress separation - Frozen stress method. Introduction to holography and Moiré's techniques.

References:

1. James. W. Dally & William E. Riley, *Experimental Stress Analysis*, McGraw-Hill.
2. Budynas, *Advanced Strength and Applied Stress Analysis*, McGraw Hill.
3. L. Sreenath, M. R. Raghavan, K. Lingaiah, G. Garghesha, B. Pant, K. Ramachandra, *Experimental Stress Analysis*, Tata McGraw Hill
4. Timoshenko & Goodier, *Theory of elasticity*, McGraw Hill, New York.

ME6631 Machine Tools Design and Analysis

Machine tool as a closed loop system – design principles of metal cutting machine tools – Machine Tool Kinematics – design of speed box and feed box – step less regulation of speed and feed-machine tool structures and their analysis-design of guide ways and power screws-design of spindles – Machine Tool Dynamics – chatter – random vibrations-stability analysis – acceptance testing of machine tools – design of modern CNC machines and mechatronic elements – positioning accuracy and repeatability of CNC machine tools – industrial design, aesthetics and ergonomics.

References:

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ME6632 Control Systems Engineering

Mathematical Modeling Of Dynamic Systems – Solving Linear, Time Invariant Differential Equations using Laplace Transform – Mathematical Modeling of Simple Mechanical Systems – State-space approach to modeling dynamic systems –Mathematical Modeling of Physical systems (Electromechanical Systems, Fluid and Thermal Systems Pneumatic Systems, Hydraulic Systems, Dynamics systems etc)

Time-Domain Analysis And Design Of Control Systems: Introduction – Block Diagrams and their Simplification – Automatic Controllers –Transient – Response Analysis – Transient – Response specifications – Improving Transient – Response and Steady – State Characteristics – Stability Analysis – Root-Locus analysis – Root

Frequency-Domain Analysis And Design Of Control Systems: Introduction – Bode Diagram Representation of the Frequency Response – Nyquist Plots and the Nyquist Stability Criterion – Design of Control Systems in the Frequency Domain Example Problems.

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