SCHEME OF STUDIES & EXAMINATION FOR

MASTER OF TECHNOLOGY

IN

MACHINE DESIGN
&
ROBOTICS

M. D. UNIVERSITY, ROHTAK
SCHEME OF STUDIES & EXAMINATIONS
MASTER OF TECHNOLOGY (Machine Design & Robotics)
EFFECTIVE FROM THE SESSION 2012-13

SEMESTER I

S.no	Course code	Course Title	Teaching schedule			Total	Class work	Examination		Total	Time of examination in hours
			L	T	P			Theory	Practical		
1	M 801A	Numerical Analysis and Optimization	3	1	0	4	50	100	-------	150	3
2	MDR 503	Artificial Intelligence	3	1	0	4	50	100	-------	150	3
3	M 805A	Experimental Stress Analysis	3	1	0	4	50	100	-------	150	3
4	MDR507	Computer Integrated Manufacturing	3	1	0	4	50	100	-------	150	3
5	MDR509	Introduction to Robotics	3	1	0	4	50	100	-------	150	3
6	M 811A	Experimental Stress Analysis lab	0	0	2	2	25	------	25	50	3
7	M 815A	Computational Lab	0	0	2	2	25	------	25	50	3
8	MDR 515	Computer Integrated Manufacturing Lab	0	0	2	2	25	------	25	50	3
		Grand Total	15	5	6	26	325	500	75	900	

Note:

1. The paper setter shall set each theory paper of 100 marks covering the entire syllabus. however, the examiner shall evaluate the performance of the student in the theory paper finally by assigning one of the grades out of A+,A,B,C,D & E. The examination of practical courses shall also be evaluated on the basis of three grades.
2. The sessionals of Theory and Practical & Seminar Courses shall also be evaluated on the basis of these grades.
3. The choice of students for any elective shall not be binding on the Deptt. To offer it.
4. The grading system is defined at the end of the scheme of studies & Examination & will be supplied by the Univ. to the examiner(s).

M. D. UNIVERSITY, ROHTAK
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SEMESTER II
EFFECTIVE FROM THE SESSION 2012-13

S.no	Course code	Course Title	Teaching schedule			Total	Class work	Examination		Total	Time of examination in hours
			L	T	P			Theory	Practical		
1	M 802A	Theory of Elasticity	3	1	0	4	50	100	-------	150	3
2	MDR 504	Design of Mechanisms and Manipulators	3	1	0	4	50	100	-------	150	3
3	M 806A	Principle of Machine Design	3	1	0	4	50	100	-------	150	3
4		General Elective – I	3	1	0	4	50	100	-------	150	3
5		General Elective – II	3	1	0	4	50	100	-------	150	3
6	M 814A	CAD/CAM Lab	0	0	2	2	25	-	25	50	3
7	M 816A	Design Practice Lab-I	0	0	2	2	25	-	25	50	3
8	MDR 540	Seminar	0	0	2	2	50	-	-------	50	3
		Grand Total	15	5	6	26	350	500	50	900	

Note:

1. The paper setter shall set each theory paper of 100 marks covering the entire syllabus. however, the examiner shall evaluate the performance of the student in the theory paper finally by assigning one of the grades out of A+,A,B,C,D & E. The examination of practical courses shall also be evaluated on the basis of three grades.
2. The sessionals of Theory and Practical & Seminar Courses shall also be evaluated on the basis of these grades.
3. The choice of students for any elective shall not be binding on the Deptt. To offer it.
4. The grading system is defined at the end of the scheme of studies & Examination & will be supplied by the Univ. to the examiner(s).

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SEMESTER III
EFFECTIVE FROM THE SESSION 2012-13

S.no	Course code	Course Title	Teaching schedule			Total	Class work	Examination		Total	Time of examination in hours
			L	T	P			Theory	Practical		
1	MDR 601	Robotics and Automation	3	1	0	4	50	100	-------	150	3
2	M 823A	Mechanical Vibration	3	1	0	4	50	100	-------	150	3
3		Elective III	3	1	0	4	50	100	-------	150	3
4	M 827A	Design Practice Lab-II	0	0	2	2	25	------	25	50	3
6	MDR 623	Automation Lab	0	0	2	2	25	-------	25	50	3
5	MDR 625	Minor Project	0	0	10	10	100	-------	150	250	
		Grand Total	9	3	14	26	300	300	200	800	

Note:

1. The paper setter shall set each theory paper of 100 marks covering the entire syllabus. however, the examiner shall evaluate the performance of the student in the theory paper finally by assigning one of the grades out of A+,A,B,C,D & E. The examination of practical courses shall also be evaluated on the basis of three grades.
2. The sessionals of Theory and Practical & Seminar Courses shall also be evaluated on the basis of these grades.
3. The choice of students for any elective shall not be binding on the Deptt. To offer it.
4. The grading system is defined at the end of the scheme of studies & Examination & will be supplied by the Univ. to the examiner(s).

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MASTER OF TECHNOLOGY (Machine Design & Robotics)

SEMESTER IV
EFFECTIVE FROM THE SESSION 2012-13

S.no	Course code	Course Title	Teaching schedule			Class work	Examination		Total
			L	T	P		Theory	E.Viva	
1	MDR 602	Dissertation	0	0	24	200	-------	400	600
		Grand Total	0	0	24	200	-------	400	600

Note:

1. The examiner shall evaluate the performance of the student finally by assigning one of the grades out of A+, A,B,C,D & E.
2. The sessional of Project shall also be evaluated on the basis of these grades.
3. The grading system is defined at the end of the scheme of studies & Examination & will be supplied by the Univ. to the examiner(s).

M. D. UNIVERSITY, ROHTAK
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MASTER OF TECHNOLOGY (Machine Design & Robotics)

LIST OF ELECTIVES

S.no	Course code	Course Title	Teaching schedule			Total	Class work	Examination		Total	Time of examination in hours
			L	T	P			Theory	Practical		
	Elective I										
1	M837	Design of Bearings and Shaft	3	1	0	4	50	100	-------	150	3
2	M838	Computer Aided Design	3	1	0	4	50	100	-------	150	3
3	M839	Design of Pollution Control Equipments	3	1	0	4	50	100	-------	150	3
4	M809A	Mechatronics and Product Design	3	1	0	4	50	100	-------	150	3
	Elective II										
1	M845	Fracture Mechanics	3	1	0	4	50	100	-------	150	3
2	MDR 524	Robot Kinematics, Dynamics and Control	3	1	0	4	50	100	-------	150	3
3	M847	Finite Element Methods	3	1	0	4	50	100	-------	150	3
4	MDR 528	Mechatronics in Manufacturing System	3	1	0	4	50	100	-------	150	3
	Elective III										
1	MDR 605	Robotic Sensors	3	1	0	4	50	100	-------	150	3
2	M849	Total Quality Management	3	1	0	4	50	100	-------	150	3
3	M851	Computer Aided Vehicle Design	3	1	0	4	50	100	-------	150	3
4	M 852	Tribology	3	1	0	4	50	100	-------	150	3

Note:

1. The paper setter shall set each theory paper of 100 marks covering the entire syllabus. however, the examiner shall evaluate the performance of the student in the theory paper finally by assigning one of the grades out of A+,A,B,C,D & E. The examination of practical courses shall also be evaluated on the basis of three grades.

2. The sessionals of Theory and Practical & Seminar Courses shall also be evaluated on the basis of these grades.
3. The choice of students for any elective shall not be binding on the Deptt. To offer it.
4. The grading system is defined at the end of the scheme of studies & Examination & will be supplied by the Univ. to the examiner(s).

SEMESTER I

M801A **L T P**
NUMERICAL ANALYSIS AND OPTIMIZATION **3 1 0**

System of linear algebraic equations and Eigen value problems: elimination method, Gauss method, Gauss-Jordan method; Eigen values and Eigen vectors, bounds on Eigen values, Jacobi methods for symmetric matrices, householder's method for symmetric matrices.

Interpolation and approximation: interpolation problem, linear interpolation, Lagrange interpolation, Newton interpolation, interpolation with equidistant points, spline interpolation, least square approximation.

Numerical differentiation and integration: differentiation of continuous functions, forward difference quotient, central difference quotient, error analysis; derivatives from differences table, higher-order derivatives, Richardson extrapolation techniques, Newton-Cotes method, trapezoidal rule, Simpson's rule, higher order rules, Romberg integration. Numerical solution of ordinary differential equations: Taylor's series method, Euler and modified Euler method, Runge-Kutta methods, Milne's method, Adam-Bashforth-Moultan method.

Optimization: basic concept of optimization, classification of optimization, optimization techniques, engineering applications of optimization. Classical optimization techniques: unconstrained optimization single-variable optimization, multivariable optimization, multivariable optimization, multivariable optimization with equality constraints: solution by direct search method, solution by Lagrange-multipliers method, multivariable optimization with inequality constraints, Kuhn-Tucker conditions.

Dynamic programming: Multistage decision process: representation of a multistage decision process, coversion of nonserial system to a serial system, types of multistage decision problems, principle of optimality, computational procedure in dynamic programming, linear programming as a case of dynamic programming, application of dynamic programming.

Text Book(s):

1. Engineering Optimization, by SS Rao; New Age International Ltd.
2. Numerical Method, by E. Balaguruswamy; Tata McGraw Hill.
3. Numerical methods for Scientific & Engineering Computation, by MK Jain, SRK Iyengar and RK Jain; New Age International Ltd.

Reference Book(s):

1. Operations Research, by Taha H Hamidi; Prentice Hall of India, New Delhi
2. Operations Research, by Philips, Revindran, Solgebery; Wiley ISE
3. Applied Numerical Analysis, by Curtis F Gerald & Patrick G Whealley; Pearson Education Ltd.

MDR503 **L T P**
ARTIFICIAL INTELLIGENCE **3 1 0**

Introduction: Intelligent Agents – Agents and environments - Good behavior – The nature of environments – structure of agents - Problem Solving - problem solving agents – example problems – searching for solutions – uniformed search strategies - avoiding repeated states – searching with partial information.

Searching techniques: Informed search and exploration – Informed search strategies – heuristic function – local search algorithms and optimistic problems – local search in continuous spaces – online search agents and unknown environments - Constraint satisfaction problems (CSP) – Backtracking search and Local search for CSP – Structure of problems - Adversarial Search – Games – Optimal decisions in games – Alpha – Beta Pruning – imperfect real-time decision – games that include an element of chance.

Knowledge representation: First order logic – representation revisited – Syntax and semantics for first order logic – Using first order logic – Knowledge engineering in first order logic - Inference in First order logic – prepositional versus first order logic – unification and lifting – forward chaining – backward chaining - Resolution - Knowledge representation - Ontological Engineering - Categories and objects – Actions - Simulation and events - Mental events and mental objects

Learning: Learning from observations - forms of learning - Inductive learning - Learning decision trees - Ensemble learning - Knowledge in learning – Logical formulation of learning – Explanation based learning – Learning using relevant information – Inductive logic programming - Statistical learning methods - Learning with complete data - Learning with hidden variable - EM algorithm - Instance based learning - Neural networks - Reinforcement learning – Passive reinforcement learning - Active reinforcement learning - Generalization in reinforcement learning.

Applications: Communication – Communication as action – Formal grammar for a fragment of English – Syntactic analysis – Augmented grammars – Semantic interpretation – Ambiguity and disambiguation – Discourse understanding – Grammar induction - Probabilistic language processing - Probabilistic language models – Information retrieval – Information Extraction – Machine translation.

TEXT BOOK(s):

1. Stuart Russell, Peter Norvig, “Artificial Intelligence – A Modern Approach”, 2nd Edition, Pearson Education / Prentice Hall of India, 2004.

REFERENCES (s):

1. Nils J. Nilsson, “Artificial Intelligence: A new Synthesis”, Harcourt Asia Pvt. Ltd., 2000.

2. Elaine Rich and Kevin Knight, “Artificial Intelligence”, 2nd Edition, Tata McGraw-Hill, 2003.
3. George F. Luger, “Artificial Intelligence-Structures and Strategies for Complex Problem Solving”, Pearson Education / PHI, 2002.

M805A **L T P**
EXPERIMENTAL STRESS ANALYSIS **3 1 0**

Strain Measurement, an ideal strain gauge, mechanical, optical, acoustical, pneumatic, dielectric and electrical strain gauges. Differential transformer and piezoelectric transducers.

Electrical Wire Resistance Strain Gauges: bonded type gauges, bonding agents, foil gauges, gauge materials. Weldable gauges. Strain gauge adhesive. Fixing of gauges. Temperature effects in bonded gauges. Gauge factor and gauge sensitivity. Measurement of stress and stress gauge.

Measuring Circuits and Strain Gauge Rosette: Potentiometer circuit, Wheatstone bridge, circuit sensitivity and output, temperature compensation and signal addition. Rectangular, delta and tee- delta rosette. Application of strain gauge in practical problems.

Whole Field Methods: Photoelasticity, stress loci, isoclinics, isostatics and isochromatics, stress optic law and strain optic law, photoelestic materials, polarization of light, plane polarized and elliptically polarized light. Brittle coating, crack pattern and crack detection in coating. Moire Fringe, geometry.

Analysis of Photoelasticity Data, polariscope, fringes due to principal stress direction and difference, model making, interpretation of isoclinics and isochromatics and fractional fringe order. Calibration through tension, beam and disc models. Reflection polariscopy. Application to stress concentration and stress intensity factor. Separation of stresses.

Text Book(s):

1. Experimental Stress Analysis, by Abdul Mubeen; Dhanpat Rai and Sons.
2. Experimental Stress Analysis, by JW Dally and WF Riley; McGraw-Hill.

Reference Book(s):

1. The Strain Gage Primer, by CC Perry and HR Lissner; McGraw-Hill.
2. Moire Fringes in Strain Analysis, by PS Theocaris; Pergammon Press.

MDR507 **L T P**
COMPUTER INTEGRATED MANUFACTURING **3 1 0**

Introduction: The meaning and origin of CIM- the changing manufacturing and management scene - External communication - islands of automation and software-dedicated and open systems-manufacturing automation protocol - product related activities of a company- marketing engineering - production planning - plant operations - physical distribution- business and financial management.

Group technology and computer aided process planning: History of group technology- role of G.T. in CAD/CAM integration - part families - classification and coding - DCLASS and MICLASS and OPITZ coding systems-facility design using G.T. - benefits of G.T. - cellular manufacturing. Process planning - role of process planning in CAD/CAM integration - approaches to computer aided process planning - variant approach and generative approaches - CAPP and CMPP process planning systems.

Shop floor control and introduction of FMS: Shop floor control-phases -factory data collection system - automatic identification methods- Bar code technology-automated data collection system. FMS-components of FMS - types -FMS workstation -material handling and storage systems- FMS layout -computer control systems-application and benefits.

CIM implementation and data communication: CIM and company strategy - system modeling tools -IDEF models - activity cycle diagram CIM open system architecture (CIMOSA)- manufacturing enterprise wheel-CIM architecture- Product data management-CIM implementation software. Communication fundamentals-local area networks -topology -LAN implementations - network management and installations.

Open system and database for CIM: Open systems-open system inter connection - manufacturing automations protocol and technical office protocol (MAP /TOP) Development of databases -database terminology- architecture of database systems-data modeling and data associations -relational data bases - database operators - advantages of data base and relational database.

TEXT BOOK(s):

1. Mikell.P.Groover “Automation, Production Systems and computer integrated manufacturing”, Pearson Education 2001.

REFERENCES(s):

1. Yorem koren, “Computer Integrated Manufacturing System”, McGraw-Hill, 1983.
2. Ranky, Paul G., “Computer Integrated Manufacturing”, Prentice Hall International, 1986.
3. David D.Bedworth, Mark R.Hendersan, Phillip M.Wolfe “Computer Integrated Design and Manufacturing”, McGraw-Hill Inc.
4. Roger Hanman “Computer Intergrated Manufacturing”, Addison – Wesley, 1997.
5. Mikell.P.Groover and Emory Zimmers Jr., “CAD/CAM”, Prentice Hall of India Pvt. Ltd., New Delhi-1,

1998.
6. Kant Vajpayee S, “Principles of Computer Integrated Manufacturing”, Prentice Hall India, 2003.
7. Radhakrishnan P, Subramanyan S.and Raju V., “CAD/CAM/CIM”, 2nd Edition New Age International (P) Ltd., New Delhi, 2000.

MDR509	**L**	**T**	**P**
INTRODUCTION TO ROBOTICS	**3**	**1**	**0**

Robot definition, Robotics and programmable automation Historical background, laws of Robotics. Robotics systems and Robot anatomy, specification of Robots. Robot geometrical configuration.

Homogeneous coordinate transformations, Mathematical description of objects. Description of a wedge by transformation matrices, Relative transformations in the robot workspace. Description of manipulator joints, Assignment of coordinate systems to robot joint and derivation of transformation matrices.

Introduction, classification of end effectors, Types of Grippers Hooks, scoops and other devices, Gripper force analysis and design of Drive system for gripper.

Euler angles for specifying orientation, Euler angles for roll-yaw-roll geometry, Gripper positioning by Euler angles for roll-yaw-roll geometry - Euler angles for roll - pitch - yaw geometry, Cylindrical Robot coordinates polar Robot coordinates, calculation of cylindrical, polar coordinates, Some applications.

Programming – powered, manual. Textual robo languages – first generation, second, future generation – VAL, VAL II, simple programming – exercises.

REFERENCE BOOKS(s):

1. Francis N. Nagy, Andras Siegler, Engineering foundation of Robotics, Prentice Hall Inc., 1987
2. Richard D. Klafter, Thomas. A, Chri Elewski, Michael Negin, Robotics Engineering an Integrated Approach, Prentice Hall of India Pvt. Ltd., 1989
3. P.A. Janaki Raman, Robotics and Image Processing an Introduction, Tata McGraw Hill Publishing company Ltd., 1995
4. Mikell P. Grooyer, Mitchell weiss, Roger N. Nagel, Nicholas G. Odrey, Industrial Robotics, Technology programming and Applications, McGraw Hill International Edition, 1986
5. S.R. Deb, Robotics Technology and flexible automation, Tata McGraw Hill Publishing company Ltd., 1994
6. Carl D. Crane and Joseph Duffy, Kinematic Analysis of Robot manipulation, Cambridge University press, 1998.

M811 A	**L**	**T**	**P**
Experimental Stress Analysis Lab	**0**	**0**	**2**

Experiments using strain gauges.

Measurement of strain, temperature effects.

Fixing of gauges on surfaces.

Experiments using photoelastic bench.

Setting of polariscope and calibration of disc, beam and tension model.

M815A	**L**	**T**	**P**
COMPUTATIONAL LAB	**0**	**0**	**2**

Modeling in 2D and image scanning using ProE.

Modeling in 3D of machine tool parts like gear details, machine tool beds, tailstocks and assembly drawings of machine tools like lathe machine components, power drives, jigs & fixtures, power presses etc using ProE.

Use of various types of surfaces in 3D modeling, animation features and other editing entities in machine tool assemblies in ProE.

Kinematic and dynamic simulation of various mechanisms in machines, process simulation like Pro-Cast, Pro-Mould and other machining features.

Tool path generation, Part Programing – G & M code development for machining operations using ProE Physical interpretation of machining features and tool geometries.

MDR515	**L**	**T**	**P**
COMPUTER INTEGRATED MANUFACTURING LAB	**0**	**0**	**2**

Computer Aided Drafting - Operating Systems - Wire Frame, Surface and Solid Modelling Simulation and Machining using CNC/DNC Machine Tools -Use of FEM packages - Relational Data Bases - Networking - Practice on Computer Aided Measuring Instruments - Image Processing - Software Development for Manufacturing - CNC Controllers - Use of advanced CNC Machine Packages - Business Data Processing.

SEMESTER II

M802A	**L**	**T**	**P**
THEORY OF ELASTICITY	**3**	**1**	**0**

State of stress at a point, stress notations, state of strain at a point and notations, states of plane stress and plane strain. Hooke's law and generalized statement of Hooke's law, stress-strain relationships. Concept of principal stress and strain, Mohr's circle.

Compatibility equations, stress function, use of stress function in solution of two dimensional problems in Cartesian coordinates, boundary conditions. Problems of cantilever, supported beam under distributed load of uniform and uniformly variable intensity. Use of Fourier series.

Two dimensional elasticity problems in polar coordinates, equation of equilibrium. Axi-symmetric problems, thick cylinder, curved bars. Hole in a plate problem. Idea of an edge dislocation.

Torsion of straight bars, elliptic and circular section. Membrane analogy, torsion of thin rectangular section. Application of energy method to torsion problem. Torsion of thin tubes.

Complex variables for curvilinear coordinates, Laplace's equation. Complex stress function and corresponding displacements. Curvilinear coordinates and stress components - elliptic hole in a uniformly stressed plate.

Text Book(s):

1. Theory of Elasticity by SP Timoshenko; McGraw-Hill (International student edition).

Reference Book(s):

1. Applied Elasticity by Zhilun Xu; Wiley Eastern Ltd.
2. Applied Elasticity by Chi-Teh Wang; McGraw-Hill.

MDR504 **L T P**
DESIGN OF MECHANISM AND MANIPULATORS **3 1 0**

Mobility analysis, Degree of freedom, mixed mobility, Total, partial and fractional DOF, Closed and open chain systems, Structural analysis and synthesis of mechanisms.

Alternative design solutions, Coding, Evaluation and selection of optimum mechanism, Type synthesis, Number synthesis, and design of mechanisms, Indexes of merit, Graphical , Algebraic and optimization techniques, Matrix method of design and analysis, Design of function path and motion generators, Structural and mechanical error, design and analysis using software like ADAMS.
Design of Manipulators: Classification, Actuation and transmission systems, Co-ordinate transformations, DH notations, Inverse and forward kinematics, Manipulators dynamics from Lagrangian and Newtonian point of view.

Text Book(s):

1. Robot Design Handbook G.B. Andeen McGraw Hill
2. Introduction to Robotics, Mechanics and Control J.J. Craig Addison Wesley
3. Robotic Manipulators: Mathematics, Programming and Control R.P. Paul MIT Press
4. Robot Dynamics and Control M. Spong and M. Vidyasagar JohnWiley, NY
5. Dextrous Robot Hands S.T. Venkataraman Springer-Verlag

M 806A **L T P**
PRINCIPLE OF MACHINE DESIGN **3 1 0**

Engineering Design; steps in designing, tasks and activities, varieties of engineering, design process and role of designer, iteration, decision making, resource conversion, systems and devices and variety of needs, need analysis, feasibility study, preliminary design, detail design, revision. Information for need and problems associated with information, variety of information.

Fundamentals of Technical Systems; system approach fundamentals, assemblies and components, interrelationships, creativity as means to synthesis of alternatives, estimating the order of magnitude, design records.

Product Planning and Development; life cycle from production to consumption and disposal, description of tasks, description of design specification and activities,

Conceptual Design; abstraction, modeling of an engineering problem; iconic, analog and symbolic models; determination of dimensions, graphics, visualization and synthesis, characteristics of a good model, value system and criterion function.

Embodiment Design; steps, rules and principles, mechanical connections, modular products, design for quality and cost. Optimization, optimum vs. optimal. Optimum and robust design. Communication and reporting, preparing and presenting the report, oral vs. written communication, aids.

Text Book(s):

1. Introduction to Engineering Design by T T Woodson; McGraw-Hill Book Co., Kogakusha Co. Ltd.
2. Mechanical Design Process by DJ Ullman; McGraw-Hill Book Co.
3. Engineering Design by GE Dieter; McGraw-Hill Book Co.

Reference Book(s):

1. Conceptual Design for Engineers by Michael French; Springer
2. The Principles of Design by NP Suh; Oxford

M 814A	**L**	**T**	**P**
CAD/CAM LAB	**0**	**0**	**2**

Develop a general purpose code to carry out the rotation of an object about an axis through two points. Develop a general purpose code to carry out: Orthogonal projection, Dimetric projection (given foreshortening factor Fz), Isometric projection, Perspective projection given Zc, ϕ_, θ_. Develop a general purpose code, given two arbitrary projections and the respective transformation matrices and the reconstructed coordinates of the vertices of the object. Develop a general purpose code to carry out the reflection of an object about an arbitrary plane passing through three points.

Develop a general purpose code for integrated: Cubic spline with differential boundary conditions, Bezier curve, B- spline- Its various types and best fit B-spline.
Given Coordinates of the control points, boundary conditions, order of the curve, if required, and Match the output to projected image of any CAD/CAM package.

Develop an optimized tool path for economic machining and generate the same in GUI
(IDEAS/ProE/CAD software) for interpretation. Study of graphics formats and conversion from one format to another. Generate the meshing of the conical cylindrical surface using any simulation package. Study of Open GL programming for the customization of any CAD package. Development of the following surface patches: Bilinear Coons Patch, Tensor Product Bezier surface.

M816A	**L**	**T**	**P**
DESIGN PRACTICE LAB – I	**0**	**0**	**2**

Design of parts of IC Engine – crankshaft, connecting rod, piston, valve gears.
Drafting with the help of standard CAD software.

SEMESTER III

MDR601	L	T	P
ROBOTICS AND AUTOMATION	**3**	**1**	**0**

Geometric configuration of robots – Manipulators – Drive systems – Internal and external sensors – End effectors – Control systems – Robot programming languages and applications – Introduction to robotic vision.

Direct and inverse kinematics – Rotation matrices – Composite rotation matrices – Euler angle representation – Homogenous transformation – Denavit Hattenberg representation and various arm configurations.

Lagrange – Euler formulation, joint velocities – Kinetic energy – Potential energy and motion equations – Generalised D'Alembert equations of motion.

General consideration on trajectory planning joint interpolation & Cartesian path trajectories.

PID control computed, torque technique – Near minimum time control – Variable structure control – Non-linear decoupled feedback control – Resolved motion control and adaptive control.

REFERENCE BOOKS:

1. Fu, K.S. Gonazlez, R.C. and Lee, C.S.G., "Robotics (Control, Sensing, Vision and Intelligence), McGraw-Hill, 1968 (II printing).
2. Wesley, E. Sryda, "Industrial Robots: Computer interfacing and Control" PHI, 1985.
3. Asada and Slotine, "Robot Analysis and Control", John Wiley and Sons, 1986.
4. Philippe Coiffet, "Robot Technology" Vol. II (Modelling and Control), Prentice Hall INC, 1981.
5. Groover M. P. Mitchell Wesis., 'Industrial Robotics Technology Programming and Applications', Tata McGraw-Hill, 1986.

M823A **L T P**
MECHANICAL VIBRATIONS **3 1 0**

Fundamentals; review of single degree freedom system, response to arbitrary periodic excitation, Duhamel's integral impulse response function, Lagrange's equation, single degree freedom forced vibration with elastically coupled viscous dampers, system identification from frequency response, Laplace formulation. Two Degree of Freedom System; free vibration of spring-mass coupled system, bending vibration of two degree of freedom system, forced vibration, vibration absorption and isolation.

Multi Degree of Freedom System; normal mode of vibration, flexibility matrix and stiffness matrix, Eigen values and vectors, orthogonal properties-modal matrix analysis, matrix inversion method, modal damping in forced vibration, numerical methods.

Vibration of Continuous Systems; systems governed by wave equations, vibration of strings and rods, Euler equation for beams, effect of rotary inertia and shear deformation, vibration of plates.

Experimental Methods; vibration exciters and measuring devices, vibration tests and analysis, tests on free and forced vibration with examples, vibration monitoring and diagnosis, case studies.

Text Book(s):

1. Theory and Practice of Mechanical Vibration by JS Rao and K Gupta; New Age Publications.
2. Mechanical Vibrations by Den Hartog; Dover Publications.

Reference Book(s):

1. Theory of Vibration with Applications by W. T. Thomson; CBC Publishers.
2. Theory of Machines by T Bevan; Longmans and Green.

M827A	**L**	**T**	**P**
DESIGN PRACTICE LAB – II	**0**	**0**	**2**

Design of power transmission systems – complete design of belt drive and gear reducer and drafting.

MDR623	**L**	**T**	**P**
AUTOMATION LAB	**0**	**0**	**2**

LIST OF EXPERIMENTS

1. Introduction to Microprocessor
2. Control of Drives using Microprocessor Kit
3. Sequencing circuits in hydraulic/pneumatics
4. Synchronizing circuits in hydraulics/pneumatics
5. Introduction to PLC
6. PLC Programming
7. PLC Ladder diagram
8. Interfacing with computers

ELECTIVES – I

M837	L	T	P
DESIGN OF BEARINGS AND SHAFT	**3**	**1**	**0**

Sliding contact bearings
Bearing classification; tribology and hydrodynamics; factors affecting choice of bearing; characteristics; types of friction in sliding element bearing; viscosity of lubricants; types of sliding contact bearings; Petroff's relation for power loss; unstable and stable lubrication; hydrodynamic theory of bearing: load carrying capacity of bearing; heating of bearings; practical bearing design; finite length bearings; pressure fed bearing; bearing materials: bearing bronzes, babbits, copper lead alloys, aluminum tin alloy, other bearing materials; bearing types; design of journal bearing.

Rolling contact bearings
Types of rolling contact bearing: radial ball bearings, angular contact ball bearings, roller bearings; friction torque due to load; frictional torque due to viscous churning of lubricants; heating of roller bearing; rolling bearing geometry; stress and deformation in rolling element; bearing deflection; permanent deformation in bearings; fatigue of rolling bearing; selection of bearing; load on bearing; combined bearing load; bearing life; equivalent load; bearing dimension code.

Shafts
Materials for shafts; strength of shafts under torsion and bending; factor of safety in shafts: fatigue strength reduction factors, modified moments of inertia of shaft section; stiffness of shafts: factors affecting shaft deflection. Complete design calculation and checking of stress concentration, shafts for power transmission through belts and gears, shaft vibrations.

Text Book(s):
1. Machine Design by Abdul Mubeen; Khanna Publishers
2. Machine Design by Shiegley; McGraw Hill
3. Design of Machine Elements by Bhandari, McGraw Hill Education

Reference book(s):
1. Machine Design by Black and Adams, McGraw Hill Education
2. Design of Machine Elements by Spotts

M838 **L T P**
COMPUTER AIDED DESIGN **3 1 0**

Transformation and Manipulation of Objects: Introduction, Transformation Matrix, 2D transformation, Arbitrary Rotation about the origin, Rotation by different angles, Concatenation, 2D transformation, Projection on to a 2D plane, Overall scaling, Rotation about an Arbitrary Point, 2D Reflection, 3D Transformation, 3D scaling, 3D Rotation of Objects, 3D Rotation about an arbitrary Axis, 3D Visualisation, reconstruction of Three Dimensional Images.

Description of Curves and Surfaces: Line Fitting, Non Linear Curve Fitting with a Power Function, Curve Fitting with a High Order Polynomial, Chebyshev polynomial Fit. Fourier Series of Discrete Systems, Cubic Spines, Parabolic Cubic Splines, Non Parametric Cubic Spline, Boundary Conditions, Bezier Curves, Differentiation of Bezier Curve Equations, B-Spline Curve, Non Uniform Rational B-Spline(NURBS), Surface creation, Coons patch, tensor product surfaces, Bezier surface, relational parametric surface, parametric spline surface, Lofted surfaces, spline blended surfaces, Tangent and Twisted vectors, Blended surfaces, Application Software.

Solid Modeling: Introduction, solid models and entities, solid representation, regularized Boolean operation, Half-spaces, B-Rep and CSG modeling techniques, analytic solid modeling, solid manipulations.

Data exchange Formats: Shape based formats; product data based formats, ISO standards, IGES- data representation, file structure and formats, processors, PDES- data representation, STEP-architecture and implementation, ACIS and DXF, creating IGES, STEP, ACIS and DXF Files.

Mechanical Assembly analysis: Assembly modeling- parts modeling and representation, Hierarchical relationships, Mating conditions, Representation schemes- Graph structure, location Graph, virtual link, generation of assembly sequences: precedence diagram, liaison sequencing analysis, precedence Graph, assembly analysis.

Hidden line and Hidden surface removal algorithms: Visibility techniques-mini-max test, containment test, surface test, edge interactions, homogeneity test, sorting, coherence, Warnock algorithm, The priority or z-Buffer algorithm, Watkinson Scan line algorithm, Ray tracing algorithm.

Text Book(s):

1. CAD/CAM Theory and Practice by Ibrahim-Zeid; Tata McGraw Hill

Reference Book(s):

1. Principles of Computer Aided Design and Manufacturing by Farid Amirouche; Pearson Prentice Hall.
2. CAD/CAM/CIM by P Radhakrishnan; New Age International.
3. Mathematical Elements of Computer graphics by Rogers and Adams; McGraw Hill
4. Computer Aided Design by Besant and Lui; Prentice Hall.

M839 **L T P**
DESIGN OF POLLUTION CONTROL EQUIPMENT **3 1 0**

Environmental pollution; Air, water and soil pollution, environment protection, abatement of emission of gas and water and soil pollution. Hazardous substances and risk analysis.

Production, emission, transfer and removal of pollutants, analysis of industrial plants, path of pollutants and carrier fluids, measures specific to plant, process and equipment.

Separation of Dust Particles from Gas Stream; harmful effects of dust, properties size distribution and movement of single particle, efficiency of separation, dry and wet processes, processes and equipment for removal of gaseous pollution. Particulate fluid dynamics, mechanism of separation, separation and fractional separation efficiency. Cyclone design, computer application in design. Single cyclone and multiple cyclone arrangement.

Wet Dust Scrubber; application in steel, foundry and chemical industries, dust particle collection-gas liquid interface, liquid jet and drops and bubbles. Column, jet, vortex, rotating disc and Venturi scrubbers. Comparison and selection of wet scrubber.

Fabric Filters; fundamentals of dust collection in fabric, effect of inertia forces, sieve effect, diffusion effect, electrostatic forces, combined effect, three dimensional and two dimensional fabric filters. Pressure drop in filters, cost of filtration. Examples of industrial applications.

Electrostatic Precipitators; fundamentals of electrostatic precipitation, elements of precipitator. Generation and transfer of electric charges, corona onset voltage, diffusion and field charging and their combination. Collection efficiency, migration velocity of dust particles, dust resistivity, design calculation.

Text Book(s):

1. Air pollution Control Equipment by H Brauer and YBG Varma; Springer Verlag.

M809A **L T P**
MECHATRONICS AND PRODUCT DESIGN **3 1 0**

Introduction to Mechatronics systems and components. Principles of basic electronics - Digital logic. Number system logic gates. Sequence logic flip Hop system. JK flip Hop. D-flip flop.

Microprocessors and their applications – Microcomputer computer structure/microcontroller. Integrated circuits-signal conditioning processes, various types of amplifiers, low pass and High pass filters.

Sensors- Sensors and transducers, displacement. Position proximity sensors. Velocity, force sensors Fluid presence temperature. Liquid level and light sensors. Selection of sensors. Actuators, Pneumatic and Hydraulic systems. Mechanical actuation system. Electrical actuation system. Other Electrical/ electronic hardware in mechatronics system.

Principles of Electronic system communication- Interfacing. AD and DA converters. Software and hardware principles and tools to build mechatronics systems. Basic system models. Mathematical models. Mechanical and other system building blocks.

System models- Engg. Systems. Rotational, translation. Electro mechanical: Hydraulic mechanical system. System transfer functions, first - second order system in series.

Design and selection of Mechatronics statements namely sensors line encoders and revolvers, stepper and servomotors ball screws, solenoids, line actuators and controllers with application to CNC system. Robots. Consumer electronics products etc. Design of a mechatronics product using available software CAD packages. MATLAB and SIMULINK.

Text Book(s):

1. Computer Control Manufacturing Systems, by Yoram Koren; McGraw Hill ISBN-007Y663793.

Reference Book(s):

1. Mechatronics, by W. Bolton; Pearson Education; Low Price Edition.
2. Automation Production System and CIMS, by Mikel P Groover; Prentice Hall.

ELECTIVES – II

M845	**L**	**T**	**P**
FRACTURE MECHANICS	**3**	**1**	**0**

History of failure by Fracture; failure of structures, bridges, pressure vessels and ships, brittle fracture, development of testing for failure, identification of reasons for failure, existence of crack, Griffith crack and experiment, energy release rate and stress for failure in presence of crack.

Stress Field around Crack Tip; revision of theory of elasticity, conformal mapping, Airy's stress function for crack tip stress field with crack emanating from straight boundary, stress state in crack tip vicinity, modes of crack face deformation, stress intensity factor and Irwin's failure criterion, fracture toughness.

Determination of Stress Intensity Factor, different specimen configuration, numerical techniques- boundary collocation and boundary integral, finite element method, experimental method- reflection and refraction polariscopy, Determination of fracture toughness.

Energy Consideration; potential energy, surface energy, plastic deformation around crack tip, energy release rate, compliance and correlation with fracture toughness, crack opening displacement (COD), COD as fracture criterion, experimental determination of COD, use of fracture toughness and COD as design criteria.

Crack Propagation; law of fatigue crack propagation, life calculation when a crack is present and loaded, microscopic aspects of crack propagation, elastic crack and plastic relaxation at crack tip.

Text Book(s):

1. Elementary Engineering Fracture Mechanics by David and Bruck; Norelco.
2. Fracture and Fatigue Control in Structure by ST Rolfe and JM Barson; Prentice Hall.

Reference Book(s):

1. Fracture Mechanics Fundamentals and Applications by TL Anderson; CRC Press.
2. Fracture of Structural Materials by AS Tetelman and AJ McEvily; John Wiley and sons.
3. Macine Design by Abdul Mubeen; Khanna Publishers.

MDR524 **L T P**
ROBOT KINEMATICS, DYNAMICS AND CONTROL **3 1 0**

Introduction, Spatial Descriptions and Transformations: Robot definition. Robot classification. Robotics system components. Notations. Position definitions. Coordinate frames. Different orientation descriptions. Free vectors. Translations rotations and relative motion. Homogeneous transformations.

Manipulator Forward and Inverse Kinematics: Link coordinate frames. Denavit-Hartenberg convention. Joint and end-effector Cartesian space. Forward kinematics transformations of position. Inverse kinematics of position. Solvability. Trigonometric equations. Closed-Form Solutions. Workspace.

Mechanics of Robot Motion: Translational and rotational velocities. Velocity Transformations. The Manipulator Jacobian. Forward and inverse kinematics of velocity. Singularities of robot motion.

Static Forces and Compliance: Transformations of static forces and moments. Joint and End-Effector force/torque transformations.

Robot Dynamics and Trajectory Planning: Lagrangian formulation. Model properties. Newton-Euler equations of motion. Simulations. Joint-based motion planning. Cartesian-based path planning.

Robot Control: Independent joint control. Feedforward control. Inverse dynamics control.
Robot controller architectures. Implementation problems.

Reference Book(s):

1. Fu K.S., Gonzalez R.C., and Lee C.S.G. *Robotics: Control, Sensing, Vision and Intelligence*. McGraw-Hill, NY, 1987. (Recommended for purchase)
2. Sciavicco L. and Siciliano B., *Modeling and Control of Robot Manipulators.* McGraw Hill, 1996.
3. Craig, J.J., *Introduction to Robotics, Mechanics, and Control.* 2nd Edition. Addison Wesley, MA, 1989. (3rd Edition, if available)
4. Spong, M.W. and Vidyasagar, M., *Robot Dynamics and Control,* Wiley, New York, 1989.
5. Paul, Richard P., *Robot Manipulators: Mathematics, Programming, and Control : the Computer Control of Robot Manipulators,* MIT Press, Cambridge, Mass., 1981.
6. Lewis F.L., Abdallah C.T., and Dawson D.M., *Control of Robot Manipulators,* Maxwell Macmillan International, 1993.
7. Ashitava Ghosal, "*Robotics, Fundamentals Concepts and Analysis*" Oxford University Press.

M847 **L T P**
FINITE ELEMENT METHOD **3 1 0**

Fundamentals; description of method, matrix techniques, large system of algebraic equations, basics of solid mechanics, stress and strain relationships in elastic behavior - linear and non linear. Variational methods in solid mechanics, minimum potential energy and minimum complementary energy, application to FE methods.

Theory of FE Method; element shapes, one-, two-, three- dimensional and axisymmetric elements, displacement models in generalized coordinates, convergence, nodal degrees of freedom, interpolation displacement models. Element stresses and strains. Element stiffness and loads, lumped loads. Variational formulation of element stiffness and lumped load, numerical integration, condensation of internal degrees of freedom.

Assemblage of Elements; discretization of a body or structure, effect of element aspect ratio, infinite bodies, higher order elements and refinement of mesh, nodal compatibility and interface displacement compatibility, assembly stiffness matrix. Boundary conditions, solution for element stress or strain.

Application of FEM to problems in mechanics, fluid flow and heat transfer. Making Computer Codes for FEM solutions.

Text Book(s):

1. Introduction to the Finite Element Method by CS Desai and JF Abel; Van Nostrand Reinhold Co.
2. Finite Element by OC Zienkiewicz.

Reference Book(s):

1. Finite Element Procedure by Klaus-Jurgen Bathe; Prentice Hall.
2. Concept and Applications of Finite Element Analysis by R Cook, D Malkus, M Plesha and R Witt; Wiley

MDR528 **L T P**
MECHATRONICS IN MANUFACTURING SYSTEM **3 1 0**

Introduction to Mechatronics systems- measurement systems, sequential controllers & electric position sensors- limit switches- photoelectric sensors- proximity sensors- Inductive, capacitive, Magnetic sensors, pneumatic limit valve - electric actuators- Linear solenoids-linear induction motors-Rotary- stepper motors.

The microprocessor systems (8085) - Architecture- Input and output peripheral circuits, the development of microprocessor systems-communications, A/D and D/A convertors.

Relays- electromechanical-solid state -ladder diagrams-sequence charts- Ladder diagram design - using sequence charts through cascade method-single path sequencing with and without sustained outputs- multi path sequencing systems- designing of ladder diagram for specific applications.

Programmable Logic controllers(PLC)- construction and basic structure- programming units-Memory - input output modules-mnemonics - Timers - internal relays-counters -shift registers-Master and jump control and Data handling- analog input/ output - programming the PLC using ladder diagrams - simple examples of PLC applications- selection of PLC.

Time delay using PLC- Time delay using Intel 555, Wind screen wiper using stepper motor control, Electronic washing machine. CASE STUDIES Pick and Place Robot - automatic camera- car engine management- bar code reader.

Reference Book(s):

1. Bolton.W., 'Mechatronics', Addison- Wesley, 2nd edition, 1999
2. Michael.B.B. Histand, 'Introduction to Mechatronics and measurement systems', McGraw-Hill International Edition, 1999
3. Goankar. R.S., 'Microprocessor Architecture Programming and Applications', Wiley Eastern, 1997

ELECTIVES – III

MDR605	**L**	**T**	**P**
ROBOTIC SENSORS	**3**	**1**	**0**

General considerations in Robot material handling, material transfer application machine loading and unloading, CNC machine tool loading, Robot centered cell.

Application of Robots in continuous arc welding, Spot welding, Spray coating, other processing Operation, Limitation of usage of robots in processing operation.

Assembly and Robot assembly automation parts presentation methods, assembly operation, compliance and the Remote center compliance (RCC) Device, assembly system configurations, Adaptable programmable assembly system, Designing for robotic assembly inspection automations - vision inspection system, robot - manipulated inspection.

Robot in hazardous and inaccessible non manufacture environments - construction trades underground coal mining, fine fighting operations, under sea operations, space operations etc. Robots in service industries - Teaching, security and household robots.

Factors influencing the choice of a robot, robot performance testing - Path/point accuracy and repeatability, maximum working envelop, kinematic and state values. Robot safety Considerations Factors affecting robot safety measures, safety features built into industrial robot, safety barriers and other devices.

Reference Book(s):

1. Mikell P. Groover, Mitchell Weiss, Roger N. Nagel and Nicholas G. Odrey, 'Industrial Robotics Technology, Programming and Applications', McGraw Hill Bokk company, 1986
2. Bernard Hodges, 'Industrial Robotics', Second Edition, Jaico Publishing House, 1993
3. Critchlow, Arthur J., 'Introduction to Robotics', Macmillan Publishing Company, 1995
4. Deb. S.R., 'Robotics Technology and Flexible Automation', Tata McGraw Hill publishing Company

M849 **L T P**
TOTAL QUALITY MANAGEMENT **3 1 0**

Introduction: Definition, Basic Approach, Guru's of TQM, Defining Quality, Historical Review. Leadership: Definitions, Characteristics of Quality Leaders, Leadership Concepts, Seven habits of highly effective people, The Deming Philosophy, Role of TQM Leaders, Implementation, Quality Council, Core values, Concepts and Framework, Strategic planning, Communications.

Customer Satisfaction and Employee Involvement: Introduction, Customer perception of Quality, Feedback, Using Customer Complaints, Service Quality, Translating Needs into Requirement, Customer Retention, Motivation, Employee Surveys, Empowerment, Suggestion System, Recognition and Reward, Gain sharing, Performance Appraisal, Unions and Employee Involvements, Benefits of Employee Involvement

Continuous Process Improvement and Benchmarking: Process, The Juran Trilogy, Improvement Strategies, PDSA Cycle, Kaizen, Re-engineering, Six Sigma. Benchmarking: Definition, Reasons to benchmark, Understanding current Performance, Planning, Pitfalls and Criticisms of Benchmarking

Tools and Techniques: Information Technology: Computers and the Quality Function, Internet and Electronic Media, Technologies of the Future. Quality Management System: ISO, benefits of Registration, Sector Specific Standards, Documentation, Internal Audits. Environmental Management System: ISO 14000, Requirements of ISO 14000, Relationship to Health and Safety

Failure Mode and Effect Analysis: Reliability, Requirements of Reliability, Failure Rate, FMEA: Team and Documentation, Stages of FMEA, Design and Process of FMEA, Products Liability: Product Safety Law, Products Liability Law, Statistical Process Control: Cause and Effect Diagram, Process Capability, Control Charts for Attributes. Experimental Design: Hypothesis, t Test, F Test, Orthogonal Design, Two Factors, Full Factorials, Fractional Factorials

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Text Book(s):

1. Total Quality Management by Besterfield Dale H; Pearson Education
2. Managing for total quality from Deming to Taguchi and SPC by N Logothetis; Prentice Hall.

Reference books:

1. Total Quality Control by AV Feigenbaum; McGraw Hill.
2. Total Quality Management by Oakland; Butterworth - Heinamann Ltd.
3. A slice by slice guide to TQM by John Gilbert; Affiliated East West Press.

M851 **L T P**
Computer Aided Vehicle Design **3 1 0**

Vehicle Frame and Suspension: Study of Loads-Moments and Stresses on Frame Members. Computer Aided Design of Frame for Passenger and Commercial Vehicles. Computer Aided Design of Leaf Spring- Coil Springs and Torsion Bar Springs.

Front Axle Steering Systems: Analysis of Loads- Moments and Stresses at different sections of Front Axle. Determination of Bearing Loads at Kingpin Bearings. Wheel Spindle Bearings. Choice of Bearings. Determination of Optimum Dimension and properties for Steering Linkages ensuring minimum error in Steering.

Drive Line and Real Axle: Computer Aided Design of Propeller Shaft. Design of Final Drive Gearing. Design of full-Floating., Semi-Floating and Three Quarter-Floating, Rear Axle Shafts and Rear Axle Housings.

Clutch: Torque capacity of Clutch. Computer Aided Design of Clutch Components. Design details of Roller and Spring type of Clutches.

Gear Box: Computer Aided Design of Three Speed and Four Speed Gear Boxes.

A. Body structure analysis for aero-dynamic shape [using Computational Fluid Dynamics]
B. Brakes – Computer Aided Design for different components of Drum and Disc brakes.
C. Design of Shock Absorber

Text Book(s):

1. Dean Averns, Automobile Chassis Design, llliffe Books
2. Heldt, P.M., Automotive Chassis, Chilton Co., New York

Reference Book(s):

1. Steeds. W., Mechanics of Load Vehicles, llliffe Books Ltd., London.
2. Giles, J.G. Steering, Suspension and Tyres, llliffe Books Ltd., London.
3. Newton, Steeds & Garret, Motor Vehicle, llliffe Books Ltd., London.
4. Heldt, P.M. Torque Converter, Chilton Books Co., New York.

M852	**L**	**T**	**P**
TRIBOLOGY	**3**	**1**	**0**

Study of various parameters: Viscosity, flow of fluids, viscosity and its variation -absolute and kinematic viscosity, temperature variation, viscosity index determination of viscosity, different viscometers, Recycling of used oil & oil Conservation. Disposal of scrap oil & oil emulsions. Friction: Introduction, Laws of friction, kinds of friction, causes of friction, friction measurement, theory of friction.

Hydrostatic lubrication: Hydrostatic step bearing, application to pivoted pad thrust bearing and other applications, hydrostatic lifts, hydrostatic squeeze films and its application to journal bearing.

Hydrodynamic theory of lubrication: Various theories of lubrication, Petroffs equation, Reynold's equation in two dimensions. Effects of side leakage - Reynolds equation in three dimensions, Friction in sliding bearing, hydro dynamic theory applied to journal bearing, minimum oil film thickness, oil whip and whirl antifriction bearing.

Friction and power losses in journal bearings: Calibration of friction loss friction in concentric bearings, bearing modulus, Summerfield number, heat balance, practical consideration of journal bearing design considerations.

Air lubricated bearing: Advantages and disadvantages application to Hydrodynamic journal bearings, hydrodynamic thrust bearings. Hydrostatic thrust bearings. Hydrostatic bearing analysis including compressibility effect. Study of current concepts of boundary friction and dry friction.

Types of bearing oil pads: Hydrostatic bearing wick oiled bearings, oil rings, pressure feed bearing, partial bearings -externally pressurized bearings. Bearing materials: General requirements of bearing materials, types of bearing materials.

Text Book(s):

1. Fundamentals of Tribology by Basu, Sen Gupta and Ahuja, PHI
2. Tribology in Industry by- Srivastava, Sushil Kumar, S. Chand &Co.

Reference Book(s):

1. Theory and Practice of Lubrication for Engineers by- Fuller, D. D., John Wiley and Sons.
2. Principles of Tribology by- Halling J., McMillan Press Ltd.
3. Machine Design by- Abdul Mubeen, Khanna Publishers
4. Tribology by– Majumdar, B.C.