M. TECH. MECHANICAL ENGINEERING (MACHINE DESIGN)
COURSE SCHEME and DETAILED SYLLABUS

Semesterwise Course Scheme

FIRST SEMESTER

	Subject Code	Subject	Credit	L-T-P	Marks Weightage Theory	Sessional	Grand total
1.	M801A	Numerical Analysis and Optimization	3	3-0-0	100	50	
2.	M803A	Instrumentation and Measurement	3	3-0-0	100	50	
3.	M805A	Experimental Stress Analysis	3	3-0-0	100	50	
4.	M807A	Metal Forming Analysis	3	3-0-0	100	50	
5.	M809A	Mechatronics and Product Design	3	3-0-0	100	50	
					Ext.	**Int.**	
6.	M811A	Experimental Stress Analysis Lab	1	0-0-2	25	25	
7.	M813A	Mechanical Measurement Lab	1	0-0-2	25	25	
8.	M815A	Computational Lab	1	0-0-2	25	25	
		Total	**18**	**15-0-6**	**575**	**325**	**900**

SECOND SEMESTER

9.	M802A	Theory of Elasticity	3	3-0-0	100	50	
10.	M804A	Design of Mechanisms	3	3-0-0	100	50	
11.	M806A	Principles of Machine Design	3	3-0-0	100	50	
12.		General Elective – I	3	3-0-0	100	50	
13.		General Elective – II	3	3-0-0	100	50	
					Ext.	**Int.**	
14.	M812A	Seminar	1	0-0-2	25	25	
15.	M814A	CAD/CAM Lab	1	0-0-2	25	25	
16.	M816A	Design Practice Lab – I	1	0-0-2	25	25	
		Total	**18**	**15-0-6**	**575**	**325**	**900**

THIRD SEMESTER

17.	M821A	Mechanical Behavior of Materials	3	3-0-0	100	50	
18.	M823A	Mechanical Vibrations	3	3-0-0	100	50	
19.	M825A	General Elective III	3	3-0-0	100	50	
					Ext.	**Int.**	
20.	M827A	Design Practice Lab II	1	0-0-2	25	25	
21.	M829A	Materials Behavior and Vibration Lab	1	0-0-2	25	25	
22.	M831A	Minor Project	5	0-0-10	150	100	
		Total	**16**	**9-0-14**	**500**	**300**	**800**

SEMESTER IV ----------

	Subject Code	Subject		Credit	L-T-P	Marks Weightage Ext.	Int.	
23.	M822A	Dissertation		12	0-0-24	400	200	
			Total	**12**	**0-0-24**	**400**	**200**	**600**

ELECTIVES I

1. M837 Design of Bearings and Shaft
2. M838 Computer Aided Design
3. M839 Design of Pollution Control Equipments
4. M840 Design of Pressure Vessels

ELECTIVES II

1. M845 Fracture Mechanics
2. M846 Design and Metallurgy of Welded Joints
3. M847 Finite Element Methods
4. M848 Materials Management

ELECTIVE III

1. M849 Total Quality Management
2. M850 Robotic Engineering
3. M851 Computer Aided Vehicle Design
4. M852 Tribology

M801A	L	T	P
NUMERICAL ANALYSIS AND OPTIMIZATION	3	0	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

Non-linear optimization: general non-linear programming problem, classification of non-linear programming problem, unconstrained optimization techniques: direct search method, gradient method. Constrained optimization techniques: separable programming, quadratic programming

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.
4. Introductory Methods of Numerical Analysis, *by* SS Sastry; Prentice Hall of India, New Delhi

M803A	L	T	P
INSTRUMENTATION AND MEASUREMENT	3	0	0

Introduction to Instrumentation
Major elements of a measurement system. Order, type of signals, response of instruments. Importance of sensors in measuring system. Errors and response characteristics of sensors. Measurement error.

Measurement Techniques
Signal conditioning: Amplification and noise filtering, impedance matching, Wheatstone Bridge technique. Digital signal processing: Sampling rate, aliasing, discretization, A/D and D/A converters, frequency content of a signal, concept of FFT. Common measuring instrument: Multimeters, oscilloscope, spectrum analyzer, display and recorder, plotter. Statistical analysis of data: Concept of normal distribution, mean and variance (standard deviation).

Displacement and Motion Measurement:
Potentiometer, linear variable differential transformer, strain gauge, proximity probe. Angular velocity measurement: Mechanical and electric tachometer. Seismic instrument: Accelerometer.
Force, Torque & Power Measurement:
Force measurement: elastic force transducer, piezoelectric force transducer, hydraulic and pneumatic method. Torque measurement: Using shaft deflection, using induced strain, torque reaction method. Power measurement: Absorption dynamometer, mechanical & hydraulic method, transmission dynamometer, torque meter.

Temperature Measurement: Thermal expansion method: Liquid-in-glass thermometer, pressure thermometer, bimetal type thermometer. Resistance Thermometer: RTD, thermistor. Thermocouple, quartz thermometer, radiation thermometer.

Pressure Measurement: Measuring static pressure: Piezometer, manometer. Measuring dynamic & static pressure: Pressure transducer, bellow-type, diaphragm-type, piezoelectric. Bourdon tube pressure gauge.

Flow Measurement
Obstruction meter: Venturi meter, nozzle, orifice meter, pitot tube. Positive displacement flowmeter: Rotary-vane meter, rotameter. Special methods: Turbine flow meter, ultrasonic flowmeter, magnetic flowmeter, hot wire anemometer, open channel flowmeter, laser Doppler flowmeter.
Examples of Instrumentation
Boiler power plant instrumentation, air conditioning plant control, industrial robotics system, etc.

Text Book(s):

1. Instrumentation and Measurement, *by* Nakara & Choudhry.
2. Instrumentation for Engineering Measurements, *by* JW Dally; John Wiley & Sons.

Reference Book(s):

1. Experimental Methods for Engineers, *by* JP Holman; McGraw Hill.
2. Mechanical Measurements, *by* Thomas Beckwith and Lewis Buck; Narosa Publishing House.

M805A	L	T	P
EXPERIMENTAL STRESS ANALYSIS	**3**	**0**	**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 out put, 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.

M807A	L	T	P
METAL FORMING ANALYSIS	**3**	**0**	**0**

Stress-Strain relations in Elastic and plastic deformations, Yield criteria for ductile metals, work hardening and anisotropy in yielding Flow curves.

Formulations of plastic deformation problems, applications of theory of plasticity for solving metal forming problems using Slab method, Upper and Lower Bound methods.

Slip Line Field Theory
Effects of temperature and strain rate in metal working, friction and Lubrication in Hot and Cold working.

Technology and analysis of important metal forming processes - Forging, Rolling, Extrusion, Wire drawing, Sheet metal forming processes like *Deep* drawing. Stretch forming. Bending.

Application of Finite Element Methods to Metal Forming Processes – special discretization. Shape function. Stiffness matrices and their assembly, Implicit and explicit formulations, Elasto-plastic approximations**,** Lagrangian vs Eularian schemes. Material integration schemes. Auxiliary equations for contact, Friction and incompressibility. Thermo-mechanical problem formulation, Steady state solutions for Drawing, forging. Rolling and Extrusion problems.

Case studies- analysis and validation of metal forming processes problems by standard softwares.

Forming defects in products and their critical effects, remedies.

An introduction to use of international standards in metal forming problem solutions and System design.

Text Book(s):

1. Metal Forming Analysis, *by* RH Wagoner; Cambridge University Press.
2. Physical Metallurgy, *by* GE Dieter; McGraw Hill.

Reference Book(s):

1. Theory of Elasticity, *by* Dally and Riley.
2. Metal Forming handbook, *by* Frontzek, M Kasparbauer; Springer Verlag.

M809A	L	T	P
MECHATRONICS AND PRODUCT DESIGN	**3**	**0**	**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 mechatronic 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 mechatronic 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.

M811A	**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.

M813A	L	T	P
MECHANICAL MEASUREMENT LAB	**0**	**0**	**2**

Experiments on measurement of linear displacement and motion by LVDT; temperature measurement by RTD Thermistor and Thermocouple; pressure and fluid flow.

Applications of plotters and recorders, Inductive Pick up Strain Gauge based cantilever, the load measurement by load cell and strain gauge based cantilever.

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.

SEMESTER 2

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

M804A	**L**	**T**	**P**
DESIGN OF MECHANISMS	**3**	**0**	**0**

MOBILITY ANALYSIS – degree of freedom (DOF) 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 methods of design and analysis, design of function, path and motion generators, structural and mechanical error, design and analysis using software like ADAMS.

Manipulators – Classification, actuation and transmission systems, coordinate transformation – DH notations, inverse and forward kinematics, manipulator dynamics from Lagrange and Newtonian point of view.

Text Book(s):

1. Mechanism Design Vol – 1,2 *by* George N Sandor and Arthur G Erdman; Prentice Hall.

Reference Book(s)*:*

1. Theory of Mechanism and Machines *by* Amitabha Ghosh and AK Mallik; EWLP, Delhi.
2. Theory of Mechanisms *by* JE Shigley and JJ Vicker; McGraw Hill.
3. Design of Machinery *by* RL Norton; McGraw Hill.
4. Mechanisms & Machines (Analysis & Synthesis) *by* Arthur Erdman.
5. Robot Engineering an Integrated Approach *by* RD Klafter, TA Chmielewski and M Negin; Prentice Hall.
6. Robotics Technology and Flexible Automation *by* SR Deb; Tata McGraw Hill.

M806A	L	T	P
PRINCIPLES OF MACHINE DESIGN	**3**	**0**	**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

M814A	L	T	P
CAD/CAM LAB	0	0	2

Section-I

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

Section-II

1. 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.

Section-III

1. Develop an optimized tool path for economic machining and generate the same in GUI (IDEAS/ProE/CAD software) for interpretation.
2. Study of graphics formats and conversion from one format to another.
3. Generate the meshing of the conical cylindrical surface using any simulation package.
4. Study of Open GL programming for the customization of any CAD package.
5. 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 3

M821A	L	T	P
MECHANICAL BEHAVIOR OF MATERIALS	**3**	**0**	**0**

Plastic Deformation and Dislocation Theory; lattice defects, deformation in a perfect lattice, dislocation in crystal and deformation, strain hardening of single crystal, low angle grain boundaries, yield point and strain ageing. Stress field of a dislocation, forces between dislocations, dislocation climb and jog, interaction with vacancy and impurity. Multiplication of dislocation and pile-up.

Behaviour under Tension; Engineering and true stress-strain curves, strength coefficient and strain hardening exponent, necking or instability in tension, effect of gauge length on strength and elongation. Effect of strain rate and temperature on tensile properties. Yield point phenomenon. Fracyre under tension and torsion.

Fatigue of Metals; Stress cycle, fatigue curve, fatigue fracture characteristics. Fatigue testing and testing machines, determination of fatigue strength. Factors affecting fatigue- size, surface, stress concentration, superimposed static stress, corrosion, contact under pressure. Understressing, coaxing and overstressing. Effect of metallurgical impurities.

Creep of Metals; Creep strain and creep-time curves, low temperature and high temperature creep theories. Fracture at elevated temperature. Stress rupture. Creep parameters and practical applications. Effect of metallurgical variables and materials for high temperature applications.

Brittle failure and Behavior under Impact; The history of failure of engineering structures and parts, high strain rate, stress concentration and low temperature effects, impact tests and results, transition temperature and factors affecting transition temperature. Flow and fracture under rapid loading. Temper and hydrogen embrittlement.

Text Book(s):

1. *Mechancial Behaviour Materials by Marc Andre Meyers, K.K. Chawla,PHI*

Reference Books:

1. Mechanical Metallurgy *by* GE Dieter; McGraw-Hill Book Co. Kogakusha Co. Ltd.
2. Fatigue of Metals *by* PG Forrest; Pergammon Press.
3. Material Science *by* Abdul Mubeen; Khanna Publishers

M823A	L	T	P
MECHANICAL VIBRATIONS	**3**	**0**	**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, eigne 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	**3**	**0**	**0**

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

M829A	L	T	P
MATERIAL BEHAVIOR AND TESTING LAB	**3**	**0**	**0**

Experiments on UTM to determine true stress, true strain, strength coefficient, strain hardening exponent etc.

Fatigue tests to determine fatigue strength.

Creep test.

ELECTIVES – I

M837A	L	T	P
DESIGN OF BEARINGS AND SHAFT	**3**	**0**	**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; Petroffs 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, aluminium 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**	**0**	**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.

M839A	L	T	P
DESIGN OF POLLUTION CONTROL EQUIPMENT	**3**	**0**	**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.

M840A	L	T	P
DESIGN OF PRESSURE VESSELS	**3**	**0**	**0**

Introduction to basic piping design criteria and codes

Pressure Design: Wall thickness determination under external pressure, internal pressure and vacuum pressure.

External Loads and Fatigue Design: Flexibility, fatigue, stress intensity factors, combined load (sustained wind, earth quake), Cold spring.

Pipe Support Design: Support types assumptions, load combinations, variable supports, lugs and attachments, pressure relief, Materials, Fabrication, Inspection and Testing.

Design of Pressure vessels subjects to internal pressure, external pressure, design of penetration, design of flanges, cone cylinder junctions. Prediction of thermal and hydraulic loads, Materials, Fabrication, Inspection and Testing.

Text Book(s):

1. Pressure Vessels: Design and Practice *by* Somnath Chattopadhyay; CRC Press

Reference Book(s):

1. Pressure Vessel Design by Donatello Annaratone

ELECTIVES – II

M845A	L	T	P
FRACTURE MECHANICS	**3**	**0**	**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.

M846A	L	T	P
DESIGN AND METALLURGY OF WELDED JOINT	**3**	**0**	**0**

Weld defects: common weld defects like weld cracks, LOP, LOF, porosity, blow holes etc., remedies and control, welding symbols.

Cost analysis of welded joints: costing factors of welding jobs- fabrication cost, material cost, preparation cost, finishing cost, overhead cost etc., economy in preparation and welding a job, labour accomplishment factor, cost calculation of welded jobs.

Prediction and control of distortion: calculation of longitudinal contraction, transverse contraction angular contraction due to single weld pass, control of welded distortion, and calculation of shrinkage.

Residual stresses: introduction, types, effect of thermal stresses, control of residual welding stresses.

Destructive and non destructive testing of welds: destructive tests, equipment required and test piece geometry for tensile test, bend test, impact test, hardness test, brittle and fatigue failure tests, non destructive tests for welds: dye penetrate inspection, magnetic particle inspection etc.

Weldability tests: definition and concept of weldabilily, purpose and types of weldability tests such as hot cracking test, root cracking tests, hydrogen induced cracking test, cruciform test.

Weld ability of metals: welding techniques, preparation of joints and electrode types for gray cast iron welding, aluminium welding, austenitic steels, titanium and its alloys.

Welding metallurgy: thermal effect of welding on parent metal, structure of fusion welds, effect of cooling rate, weld metal solidification and heat affected zone.

Automation in welding: introduction and concept, classification of welding automation, economics of welding automation.

Text Book(s):

1. Welding Technology *by* RS Parmar
2. Welding Technology *by* AC Devis.
3. Welding and Welding Technology *by* Little; Tata McGraw Hill.

Reference book(s):

1. Modern Welding Technology *by* HB Carry; Prentice Hall.
2. AWS Welding Handbook (IV-VI edition)
3. Elements of Machine Design *by* Pandya and Shah.

M847A	L	T	P
FINITE ELEMENT METHOD	**3**	**0**	**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

M849A	L	T	P
MATERIALS MANAGEMENT	**3**	**0**	**0**

Introduction: introduction to material management and productivity, functions of material management, organization structures in material management, role of material management techniques in improved material productivity.

Material planning: objectives, material requirement planning, manufacturing resource planning, JIT production planning, strategic material planning, material control: acceptance, sampling, inspection, make or buy decision, simple cost analysis, economic analysis, break even analysis, break even point theory, whether to add or drop a product line store management and warehousing, product explosion.

Purchasing: importance of good purchasing system, organization of purchasing functions, purchase policy and procedures, responsibility and limitations, purchasing decisions, purchasing role in new product development, role of purchasing role cost reduction, negotiations and purchase, purchasing research: identification of right sources of supply, vendor rating, standardization, vendor certification plans, vendor and supply reliability, developing new source of supply.

Cost reduction: cost control vs cost reduction, price analysis, material cost reduction techniques, variety reduction, cost reduction and value improvement, techniques of cost control, standard costing, cost effectiveness, cost analysis for material management, material flow cost control.

Inventory management, inventory vs stores, types of inventory, inventory control, inventory build-up, EOQ, various inventory models, inventory models with quantity discount, exchange curve concept, coverage analysis, optimal stocking and issuing policies, inventory management of perishable commodities, ABC - VED analysis, design of inventory distribution systems, surplus management, information system for inventory management, case studies.

Text Book(s):

1. Material management *by* WR Stelzer Jr; Prentice Hall
2. Material management *by* DS Ammer & Richard Erwin.

Reference book(s):

1. Material management *by* AK Dutta; Prentice Hall
2. Material management: An integrated approach *by* P Gopalakrishnan & M Sundersen; Prentice Hall

ELECTIVES –III

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

M850	L	T	P
ROBOTIC ENGINEERING	**3**	**0**	**0**

Introduction: Automation and Robotics, Historical Development, Definitions, Basic Structure of Robots, Robot Anatomy, Complete Classification of Robots, Fundamentals about Robot Technology, Factors related to use Robot Performance, Basic Robot Configurations and their Relative Merits and Demerits, Types of Drive Systems and their Relative Merits, the Wrist & Gripper Subassemblies. Concepts and Model about Basic Control System, Transformation and Block Diagram of Spring Mass System, Control Loops of Robotic Systems, PTP and CP Trajectory Planning, Different Types of Controllers, Control Approaches of Robots

Kinematics of Robot Manipulator: Introduction, General Description of Robot Manipulator, Mathematical Preliminaries on Vectors & Matrices, Homogenous Representation of Objects, Robotic Manipulator Joint Coordinate System, Euler Angle & Euler Transformations, Roll-Pitch-Yaw (RPY) Transformation, Relative Transformation, Direct & Inverse Kinematics Solution, D H Representation & Displacement Matrices for Standard Configurations, Geometrical Approach to Inverse Kinematics. Homogeneous Robotic Differential Transformation: Introduction, Jacobian Transformation in Robotic Manipulation.

Robotic Workspace & Motion Trajectory: Introduction, General Structures of Robotic Workspaces, Manipulations with n Revolute Joints, Robotic Workspace Performance Index, Extreme Reaches of Robotic Hands, Robotic Task Description. Robotic Motion Trajectory Design - Introduction, Trajectory Interpolators, Basic Structure of Trajectory Interpolators, Cubic Joint Trajectories. General Design Consideration on Trajectories- 4-3-4 & 3-5-3 Trajectories, Admissible Motion Trajectories.

Dynamics of Robotic Manipulators: Introduction, Bone, Graph Modeling of Robotic Manipulators, Examples of Bond Graph Dynamic Modeling of Robotic Manipulator. Brief Discussion on Lagrange-Euler (LE) Dynamic Modeling of Robotic Manipulators- Preliminary Definitions, Generalized Robotic Coordinates, Dynamic Constraints, Velocity & Acceleration of Moving Frames, Robotic Mass Distribution & Inertia Tensors, Newton's Equation, Euler Equations, The Lagrangian & Lagrange's Equations. Application of Lagrange-Euler (LE) Dynamic Modeling of Robotic Manipulators: - Velocity of Joints, Kinetic Energy T of Arm, Potential Energy V of Robotic Arm, The Lagrange L, Two Link Robotic Dynamics with Distributed Mass, Dynamic Equations of Motion for A General Six Axis Manipulator.

Robot Teaching: Introduction, Various Teaching Methods, Task Programming, survey of Robot Level Programming Languages, A Robot Program as a Path in Space, Motion Interpolation, WAIT, SIGNAL & DELAY Commands, Branching, Robot Language Structure, various Textual Robot Languages Such as VAL II, RAIL, AML and their Features, Typical Programming Examples such as Palletizing, Loading a Machine Etc.

Robot Sensing & Vision: Various Sensors and their Classification, Use of Sensors and Sensor Based System in Robotics, Machine Vision System, Description, Sensing, Digitizing, Image Processing and Analysis and Application of Machine Vision System, Robotic Assembly Sensors and Intelligent Sensors.

Industrial Applications: Objectives, Automation in Manufacturing, Robot Application in Industry, Task Programming, Goals of AI Research, AI Techniques, Robot Intelligence and Task Planning, Modern Robots, Future Application and Challenges and Case Studies.

Text Book(s):

1. A Robot Engineering Textbook *by* Mohsen Shahinpoor; Harper & Row publishers, New York.
2. Robotics, control vision and intelligence *by* Fu, Lee and Gonzalez; McGraw Hill International.
3. Introduction to Robotics *by* John J. Craig; Addison Wesley Publishing.
4. Robotics for Engineers *by* Yoram Koren; McGraw Hill International.
5. Industrial Robotics *by* Groover, Weiss, Nagel; McGraw Hill International.
6. Robotics and Control by Nagrath-Mittal, TMH

Reference Book(s):

7. Robot Technology Fundamentals *by* Keramas, Thomson; Vikas Publication House.
8. Company Fundamentals of Robotics Analysis and Control *by* Schilling; Prentice Hall.
9. Introduction to Robotics *by* Niku; Pearson Education, Asia.
10. Foundation of Robotics *by* Yoshikawa; Prentice Hall (EEE).
11. Robotic Engineering - An Integrated approach *by* Klafter, Chmielewski and Negin; Prentice Hall.
12. Robot Vision and Sensor Controls Vol-3 *by* Rooks B; North Holland.

M 851

Computer Aided Vehicle Design

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3	0	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 Chasses Design, lliffe Books
2. Heldt, P.M., Automotive Chasses, Chilton Co., New York

Reference Book(s):

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

M852	L	T	P
TRIBOLOGY	**3**	**0**	**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, Re-cycling 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 BOOKS:

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

REFERENCE BOOKS

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.