- **B.E. [Mechanical]**

B.E. 2003 Structure (w.e.f. July – 2006)

Code	Subject	Teaching Scheme		Examination Scheme				
		Lect.	Pract/Dwg	Paper	TW	Oral	Pr.	Total
402041	Mechanical System Design	4	2	100 **	25	50	-	175
402042	Dynamics of Machinery	4	2	100	25	50	-	175
402043	Mechatronics	4	2	100	25	50	-	175
402044	Gas Turbines & Jet Propulsion	4	-	100	-	-	-	100
402045	Elective I	4	-	100	-	-	-	100
402046	Project Work	-	2	-	-	-	-	-
Total of First Term		**20**	**8**	**500**	**75**	**150**	**-**	**725**

SECOND TERM

Code	Subject	Teaching Scheme		Examination Scheme				
		Lect.	Pract/Dwg	Paper	TW	Oral	Pr.	Total
402046	Project Work	-	6	-	100	50	-	150
402047	CAD/CAM & Automation	4	2	100	25	50	-	175
402048	Power Plant Engineering	4	2	100	25	50	-	175
402049	Industrial Fluid Power	4	2	100	25	50	-	175
402050	Elective II	4	-	100	-	-	-	100
Total of First Term		**16**	**12**	**400**	**175**	**200**	**-**	**775**

Elective I		**Elective II**	
402045	Product Design & Development	402050	Robotics
402045	Non-Conventional Production Processes	402050	Computational Fluid Dynamics
402045	Alternative Energy Sources	402050	Energy Management
402045	Kinematic Analysis & Synthesis	402050	Rapid Prototyping
402045	Operations Research	402050	Reliability Engineering
402045	Costing & Cost control	402050	Automobile Engineering

** Theory paper of 4 Hours duration.

B.E.(MECH) SYLLYBUS TERM –I

402041:- MECHANICAL SYSTEM DESIGN

Teaching Scheme:
Lecture : 4 Hrs / Week
Practical : 2 Hrs / Week

Examination Scheme:
Paper :100 Marks (4 Hous)
Term Work : 25 Marks
Oral : 50 Marks

Unit 1
Design Of Cylinders and pressure vessels:

Thick and thin cylinders – Thin cylindrical and spherical vessels – Lame's equation – Clavarino's and Birnie's equations – Design of hydraulic and pneumatic cylinders – Auto frettage and compound cylinders – Gasketed joints in cylindrical vessels. Modes of failures in pressure vessels. Unfired pressure vessels – Classification of pressure vessels as per I. S. 2825 – categories and types of welded joints – weld joint efficiency – Corrosion, erosion and protection vessels, stresses induced in pressure vessels, materials of construction. Thickness of cylindrical and spherical shells and design of end closures as per code – Nozzles and Openings in pressure vessels –Reinforcement of openings in shell and end closures. Area compensation method – Types of vessel supports.

Unit 2
Optimum design:
Objectives of optimum design –Johnson's Method of Optimum Design (MOD). Adequate and optimum design. Primary, subsidiary and limit equations – Optimum design with normal and redundant specifications of simple machine elements like tension bar, transmission shaft, helical spring.

Unit 3
Design of Flywheel:
Design of flywheel, Fundamental equation of motion – torque analysis – disk and rimmed flywheels – Stresses in flywheel rim and spokes – Design of disc and and rimmed flywheels for various applications. Standard dimensions of flywheels.

Unit 4
Statistical consideration in design:
Frequency distribution – Histogram and frequency polygon – Normal distribution – Units of measurement of central tendency and dispersion – Standard variable – population combinations – Design and natural tolerances –Design for assembly- Statistical analysis of tolerances – Mechanical reliability and factor of safety.

Design for manufacture:

General principles of design for manufacture and assembly (DFM & DMFA). Principles of design of castings and forgings – Design for machining – Design for powder metallurgy – Design for welding

Unit 5
Design of gear boxes for machine tool applications:
Basic considerations in design of drives. Determination of variable speed range- graphical representation of speed and structure diagram- deviation diagram- ray diagram- selection of optimum ray diagram- difference between number of teeth of successive gears in a change gear box- analysis of twelve speed gear box- compound ray diagram.

Aesthetic and ergonomic considerations in design of products:
Basic types of product forms – Designing for appearance – Shape, features, materials and finishes, proportions symmetry, contrast etc. – Morgan's colour code. Ergonomic considerations - Relation between Man, machine and environmental factors. Design of displays and controls.
Practical examples of products or equipments using ergonomic and aesthetic design principles.

Unit 6
Design of Material Handling System :

System concept, basic principles, objectives of material handling system, unit load an containerization.
Belt conveyors:
Flat belt and troughed belt conveyors, capacity of conveyor, rubber covered and fabric ply belts, belt tensions, conveyor pulleys, belt idlers, tension take-up systems, power requirement of horizontal belt conveyors for frictional resistance of idler and pulleys.

Term Work:

The term work shall consist of ONE design project. The design project shall consist of two imperial size sheets - one involving assembly drawing with a part list and overall dimensions and the other sheet involving drawings of individual components, manufacturing tolerances, surface finish symbols and geometric tolerances should be specified so as to make it working drawing. A design report giving all necessary calculations of the design of components and assembly should be submitted in a separate file. Projects shall be in the form of design of mechanical systems such as pressure vessel, Conveyor system, Multi speed gear box, Hoisting system.

Assignments:
Three assignments based on any *one* of the following topics from each of the three groups.Group I : Sr. No. 1 to 4, Group II : Sr. No. 5 to 8, Group III : Sr. No. 9 to 11.

1. Modern engineering materials and their applications / evaluation methods for material selection.
2. Piping design.
3. Product design involving ergonomic and aesthetic considerations.
4. Cost estimation of a product.
5. Value engineering
6. Concurrent engineering
7. Reverse engineering.
8. Design for manufacturing and assembly.
9. Designing for environment.
10. Designs in relation to patents, trade mark and copy right.
11. Requirements of design office as per I.S.O. 9000.

Note: -Assignments will be treated as part of term work.

Reference Books

1. Shigley J.E. and Mischke C.R., "Mechanical Engineering Design", McGraw Hill Pub. Co. Ltd.
2. M.F.Spotts – 'Mechanical design analysis' Prentice Hall Inc.
3. Bhandari V.B., "Design of Machine Elements", Tata McGraw Hill Pub. Co. Ltd.
4. Black P.H. and O. Eugene Adams, "Machine Design", McGraw Hill Book Co. Inc.
5. "Design Data", P.S.G. College of Technology, Coimbatore.
6. I.S. : 2825 Code for unfired pressure vessels.
7. Johnson R.C., "Mechanical Design Synthesis with Optmisation Applications", Von-Nostrand-Reynold Pub.
8. Dieter G.E., "Engineering Design", McGraw Hill Inc.
9. S.K. Basu and D.K. Pal – 'Design of machine tools' Oxford and IBH Pub. Co.
10. N.K.Mehta – 'Machine tool design' Tata McGraw Hill Pub. Co.
11. S.P. PATIL – 'Mechanical System Design' JAICO students Ed., JAICO Publishing House, Delhi
12. Rudenko – 'Material Handling Equipment' M.I.R. publishers, Moscow

402042 DYNAMICS OF MACHINERY

Teaching Scheme:
Lecture : 4 Hrs / Week
Practical : 2 Hrs / Week

Examination Scheme:
Paper :100 Marks
Term Work : 25 Marks
Oral : 50 Marks

UNIT 1 GYROSCOPE:
Principles of gyroscopic action , precession , gyroscopic couple, effect of gyroscopic couple on ships, aeroplane and vehicles etc.

UNIT 2 BALANCING:
Balancing of rotating masses in one and several planes, balancing of reciprocating masses in single and multi cylinder engines—inclined, radial and Vee type. Primary and secondary balancing analysis. Concept of direct and reverse cranks. Static and dynamic balancing machines.

UNIT 3 FREE VIBRATION OF LONGITUDINAL AND TORSIONAL SYSTEMS
Introduction - Introduction to vibration, elements of a vibratory system, S.H.M., degrees of freedom, modeling of a system, Concept of linear and non-linear systems, equivalent spring, damper and inertia for linear and torsional systems.

Undamped free vibrations – Single degree of freedom – Natural frequency by Equilibrium and Energy methods, natural frequency of torsional vibrations.
Damped free vibrations – Single degree of freedom- Different types of damping, free vibrations with viscous damping - over damped , critically damped and under damped systems, initial conditions, logarithmic decrement, Dry friction or Coulomb's damping – frequency and rate of decay of damped vibrations.

UNIT 4
DAMPED FORCED VIBRATION – SINGLE DEGREE FREEDOM : Forced vibrations of longitudinal and torsional systems, harmonic excitation, excitation due to reciprocating and rotating unbalance, magnification factor, resonance, phase angle, base excitation, force and motion transmissibility, vibration isolation.

UNIT 5
UNDAMPED FREE VIBRATIONS - TWO DEGREES OF FREEDOM: Introduction, natural frequency of longitudinal vibration by equilibrium method, mode shapes, Torsional vibrations of two rotor and three rotor systems – natural frequency, mode shapes and node points, geared systems.

UNIT 6
VIBRATION MEASUREMENTS
Measurement of displacement, velocity, acceleration, frequency and damping. Different types of pick-ups, exciters, vibration meter, Introduction to FFT Spectrum Analyzer and vibration monitoring of machines.

CRITICAL SPEED: whirling of horizontal and vertical shafts carrying single rotor. Damped and undamped systems.

Reference Books:

1. Beven T. " Theory of Machines "
2. Jagdishlal, . " Theory of Machines "
3. Shigley J. E. and Uicker J. J. . " Theory of Machines and Mechanisms" International Edition , McGraw Hill Inc.
4. Grover G. K. "Mechanical Vibrations " , Nem Chand and Bros.
5. Rao S. S. "Mechanical Vibrations " , Addison Wiley Publishing Co. , World Student Series.
6. Seto W. W. "Mechanical Vibrations " Schaum Publishing Co. , New York.
7. Hannah and Stephans, " Mechanics of Machines " ,Edward Aronold Publication.
8. A. Gosh & Malik , "Theory of Mechanism and Machines" ,East – West Pvt Ltd.
9. Meirovitch, "Elements of Mechanical Vibrations", Tata McGraw Hill

Term Work

The Term Work shall consist of "eight" experiments of which any seven from experiment no. 1 to 9 and experiment no. 10 (compulsory).

1. Verification of principle of gyroscope and gyroscopic couple, magnitude.
2. Study of any two gyro controlled instruments.
3. Experimental verification of dynamic balancing of rotating masses.
4. To determine the natural frequency of damped vibration of single degree freedom system and to find its damping coefficient.
5. To verify natural frequency of torsional vibration of two rotor system and position of node.
6. To determine critical speed of single rotor system.
7. To determine resonance frequency of transverse vibration of beam..
8. To determine the frequency response curve under different damping conditions for single degree freedom system of vibration.
9. To study shock absorbers and to plot transmissibility curve.
10. Measurement of vibration parameters like frequency, amplitude, velocity, acceleration etc. of any vibrating system by using vibration measuring instruments.

Oral shall be based on the term work prescribed and presented in the form of a journal.

402043 : MECHATRONICS

Teaching Scheme	Examination Scheme
Lectures : 4 Hrs/Week	Paper : 100 Marks
Practicals : 2 Hrs/Week	T/W : 25 Marks
	Oral : 50 Marks

Unit 1

Introduction to Mechatronics : Mechatronic system, measurement systems, control systems and response of systems.

Measurement systems : static characteristics

Flow measurement : Rotameter, anemometer and comparison of characteristics of different flow meters.

Pressure measurement : Mcleod gauges, comparison of characteristics of different pressure measuring devices.

Unit 2

Level measurement, strain measurement – strain gauges, theory, types, strain gauge circuits, temperature compensation, load cells.

Temperature measurement : RTD, Thermocouples, pyrometers.

Displacement and position sensors : LVDT, optical encoders – transnational and rotary.

Unit 3

System Models : Mathematical models, introduction to mechanical, electrical, fluid and thermal systems. Rotational and transnational systems, electro – mechanical, hydraulic – mechanical systems.

Control Systems : open loop, closed loop systems, transfer functions, feed back and feed forward control systems and their applications.

Unit 4

System Response, modeling of dynamic systems, dynamic response of first order, second order systems to step, ramp and impulse inputs. Transfer functions, Bode plots, stability of systems.

Control Actions : On – Off, proportional, proportional + integral, P + D . proportional + integral + derivative control actions.

Control systems Components :

Transmitters,controllers/pressure/flow/level/temperature/limit/proximimity/magnetic switches and relays.

Unit 5

Analog signal processing, introduction, principle, passive circuits, operational amplifiers - characteristics and specifications. Op – amp circuits for inverting, non inverting, difference amplifiers, integrator, differentiator, comparator and sample and hold applications (no analytical treatment.)

Digital Signal Processing : Timing diagrams, sequential logic, flip flops, D flip flop, JK flip flop, master slave flip flop. Applications of flip flop, decade counters, Schmitt trigger, 555 timers. A/D and D/A converters.

Unit 6

Programming Logic Controllers : Relay logic, basic structure, input/output processing, timers, internal relays and counters, shift resisters, ladder diagram and programming, selection of PLCs, introduction to microcontroller.

List of Experiments :

Minimum of 10 experiments from the following; out of which experiment no. 12 is compulsory, four shall be from serial no. 1 to 5, three from serial no. 6 to 11 and two from 13 to 17. Record of experiments and assignments shall be submitted in the form of journal.

1. Calibration of flow meters.
2. Calibration of Thermocouples/ RTD.
3. Study of Load Cells.
4. Vibration measurement using accelerometers.
5. Displacement measurement/ level measurement.
6. Verification of P, P+I, P+D, P+I+D control actions.
7. Study of XY position control systems.
8. Study of linear conveyor control system.
9. Study of rotary table positioning systems.
10. Study of different switches and relays.
11. Analysis of control system using software like MATLAB/SIMULINK or equivalent.
12. Development of ladder diagram/programming PLC for level control, position control or any other mechanical engineering application.
13. Study of A/D and D/A converters.
14. Study of Flip Flops and Timers.
15. Study of Application of Op – Amp circuits.

16. Study of Data acquisition system.
17. Study of Microcontrollers.

Text/Reference Books

1. Doebelin E. O., Measurement System – Application and Design, Tata McGraw Hill Publications Ltd, New Delhi.
2. Bolton W. , Mechatronics – Electronics Control Systems in Mechanical and Electrical Engineering, Pearson – Education (Singapore) Pte. Ltd.
3. Rangan C. S., Sarma G. R., Mani V. S., Instrumentation – Devices and Systems, Tata McGraw Hill Publishing Company Ltd., New Delhi.
4. Histand B. H., Alciatore D. G., Introduction to Mechatronics and Measurement Systems.
5. Johnson C. D. ' Process Control Instrumentation Technology, Prentice Hall of India Pvt Ltd., New Delhi.
6. HMT, Mechatronics, HMT.
7. Mahalik N. P., Mechatronics – Principles, concepts and applications, Tata McGraw Hill Publishing Company Ltd, New Delhi.
8. Kolk R. A., Shetty D., Mechatronics Systems Design, Vikas Publishing Manual, Delhi.

GAS TURBINES & JET PROPULSION (402044)

Teaching Scheme	Examination Scheme
Lectures : 4 hrs/wk	Theory : 100 marks

Unit I :- **8 Hrs.**

Fundamentals of gas Dynamics. Conservation of mass, momentum and energy equations for one dimensional steady state compressible fluid flow. Sonic velocity, Mach number, Mach cone, Mach angle. Stagnation temperature, pressure and enthalpy. Isentropic flow through a passage of varying cross section. Choking in isentropic flow. Operations of nozzles under varying pressure ratios – converging nozzles – converging – diverging nozzles. Adiabatic flow with frictions in constant area ducts. Fanno lines, Fanno relations for perfect gases. Concept of Rayleigh lines. Normal shock. Strength of shock wave and shocks in converging diverging nozzles.

Unit II :- **8 Hrs.**

Centrifugal & axial flow compressors – Centrifugal compressor construction, flow process on T– S diagram, velocity diagram and Euler's work. Slip factor and its effect on work input. Actual work input, Dimensionless parameters of centrifugal compressors pre-whirl losses in centrifugal compressor, surging. Axial flow compressor – constructional details, velocity triangles and work done. Pressure rise and aerodynamic force in flow with and without friction. Cascade efficiency, Dimensionless parameters, losses in axial compressor stage choking flow. Stalling characteristics of centrifugal and axial flow compressor. Comparison between centrifugal & axial flow compressors. Compressor materials.

Unit III :- **8 Hrs.**

Gas turbine cycles, Simple open cycle Brayton cycle Gas turbine – Thermal efficiency. Actual Brayton cycle – its thermal efficiency. Cycle air rate, work ratio optimum pressure ratio. Means of improving the efficiency and specific output. Gas turbine with reheat, inter-cooling. Regeneration. Effect of these on efficiency

effect of operating variables on thermal efficiency, air rate and work ratio, water injection. Closed cycle gas turbines semi-cooling cycle gas turbine. Advantages & disadvantages of gas turbine over steam turbine and petrol & diesel engines.

Unit IV :- **8 Hrs.**

Impulse & reaction turbines: Introduction A single impulse and reaction stage, Multistage machines, velocity triangles. Work output, blade loading and flow coefficients, Blade & stage efficiencies. Maximum utilization factor, velocity, pressure compounding reaction turbines, blade to gas speed ratio losses and efficiencies performance graphs.

Unit V :- **8 Hrs.**

Combustion systems:- introduction, combustion theory, factors affecting combustion chamber design & performance form of combustion systems. Requirement of combustion chamber process of combustion. Combustion chamber geometry mixing & dilution. Combustion chamber arrangements fuels for gas turbines flame tube cooling Fuel injection & ignition. Fuel for gas turbine & pollution problems. Materials for gas turbines factors influencing selection of materials. Requirements for high temperature materials - some typical materials. Blade cooling - recent developments & typical applications.

Unit VI :- **8 Hrs.**

Jet propulsion cycles – introduction, Ramjet, Pulse jet, Turbo prop – Turbojet, Turbofan engines, Scramjet. Thrust equations, specific thrusts, thrust augmentation, efficiencies, parameters affecting performance; thurst augmentation fuels for jet engines. Rocket propulsion – introduction, classification. Chemical Rockets liquid propellants. Solid propellant, Nuclear rocket engines. Ion rocket, magneto plasma rocket engines solar rocket engines, staging of rockets, applications of rockets.

Reference Books

1) Gas turbine - V Ganesan - Tata Mcgraw hill
2) Steam & Gas Turbines - R Yadav, - Central Publication
3) Gas turbine & Propulsive Systems - PRKhajuria Dubey Dhanpat Rai & Co(P) Ltd.
4) I C Engines - Domkundwar Dhanpat Rai & Co(P) Ltd.
5) Gas turbine Theory- Hih Sarvana muttoo, GFC Rogers, H Cohen – Pearson Edu. Asia

402045 : PRODUCT DESIGN & DEVELOPMENT

Teaching Scheme **Examination Scheme**

Lectures: 4Hrs/Week Paper : 100 Marks

UNIT I

Product Development history and product Development process tool.

Product development verses design, modern product development theories and methodologist in design. Product development teams. Product development planning, technical and business concerns. Understanding customer needs, Establishing product functions. Functional decomposition, modeling process,

Function trees system functionality, augmentation. Aggregation, common basis, functional modeling methods.

UNIT II
Product tear down and experimentation, benchmarking and establishing engineering specification. Product portfolios and portfolio architecture.

Tear down process, tear down methods, post teardown reporting, benchmarking approach, support tools, setting specifications, portfolio architecture, types, platform, functional architecting, optimization selection. Product modularity, modular design.

UNIT III
Concepts and Modeling

Generation of concepts, information gathering and brain storming, directed search, morphological analysis, combining solutions. Decision making, estimation of technical feasibility, concept selection process, selection charts, measurement theory, numerical concept scoring, design evaluation scheme, concept embodiment, geometry and layout, system modeling, modeling of product metrics, selection of model by performance specifications, physical prototyping, informal and formal models.

UNIT IV
Design for manufacturing and assembly.

Design for the environment, design for assembly, piece part production, cost analysis, environmental objectives, life cycle assessments, techniques to reduce environmental impact like minimum material usage, disassembly, recycle ability, remanufacturing, high impact material reduction, energy efficiency, regulation and standards.

UNIT V
Analytical and Numerical Solutions
Solution Definition, Spread sheet search, optimization, Analytical formulation, practical optimization, Numerical search, stopping criteria, sensitivity analysis Global optimality, product applications.

UNIT VI
Physical prototypes, physical models and experimentation. Design for Robustner, prototype essentials, types of prototype, uses of prototype, Rapid prototyping, Scale, Dimensional Analysis and similitude, Design of experimentation Reduce tests and fractional experiments, statistical analysis, product application of experiments, statistical analysis, product application of physical modeling and design of experiments, Quality design theory, Noise variable matrix, Design variable matrix, Experimental matrix, selection of target designs, parametric design, Advance analysis : probability theory, sizing and variation.

References :

1. Product Design : fundamentals and methods NFM Roozenburg, J Eekels, John Wiley and sons Ltd. Price Rs. 2265.00
2. Product Design for manufacturing and Assembly Geoftry Boothroyd, peter dewhurst, Winstrn Knight Marcel Dekker Inc., USA. Price Rs.8201.00
3. Product Design : A practical guide to systematic methods of new product development, Mike Baxter, Champman and Hall. Price Rs1436.00.
4. Product Design and manufacturing, AK Chitale; R.C. Gupta, Prentice – Hall India. Price Rs.250.00

5. Product Design and Manufacture John R.Lindbeck, Prentice Hall International Editime. Price Rs.1001.00
6. Product Design :Techniques in Revenue Engineering and New product development, Kevin Otto, Kristin wood Pearson Education Inc. Price Rs.495.00

402050 : ALTERNATIVE ENERGY SOURCES (ELECTIVE I)

Teaching scheme	Examination
Lecturers: 4 Hrs/ Week	Theory paper: 100 Marks

Unit 1

Solar Energy : Availability, limitations, energy efficiency by 1st and 2nd law of thermodynamics, application of solar energy.

Solar Radiation : Structure of the sun, energy radiated by the sun, angular relationship of earth and sun position, measurement of solar radiation on horizontal and tilted surface.

(6)

Unit 2

Flat Plate collectors : Types and constructional details of flat plate collector, energy balance and efficiency for a flat plate collector, simple equation and performance curves, selection of flat plate collector.

Solar heating systems : Active and passive solar water and space heating systems, solar heating economics, solar air heating systems and drying systems, types of dryers used. (8)

Unit 3

Solar concentrator : Limitations of flat plate collectors, various types of concentrators, their advantage, simple thermal energy balance equations, heliostats. selection of various materials for concentrators and reflecting surfaces.

Solar distillation systems : Various solar stills and selection, constructional details.

Solar ponds–introduction, description, performance analysis. (8)

Unit 4

Solar electric power : Solar photovoltaic system, description and working, materials used and their applications and performance, types of solar thermal power plant, working substance used, temperature required, various systems used.

Wind Energy : Availability of wind, various types of wind mills and their constructional details and performance study, selection, sizing and siting, micro Hydel power plants. (8)

Unit 5

Geothermal Energy : Sources and application of Geothermal energy, various types of geothermal power plants.

Tidal Energy : Tidal energy available in India, suitable locations, study of various tidal energy power plants, characteristics of turbines required.

Ocean thermal energy : Comparison of various plants, principle of working.

Fuel cells : types and working, analysis of operations, actual performance.

(8)

Unit 6

An overview of other renewable devices, systems : Bio mass energy, energy from biomass, methods of obtaining energy from biomass – direct and indirect methods, biomass gasification.
Biogas: chemistry of biogas generation, variable affecting simple gas plants, use of bigas for diesel engine, case study.
Emission norms : emission from renewable fuels and its effect on environment, study of environment protection norms ISO 14000, 16000 etc. (7)

Reference Books :
1) Solar Energy – Dr. S. P. Sukhatme, Tata McGraw Hill
2) Solar Energy Utilization – G.D. Rai, Khanna Publishers
3) Non Conventional Sources of Energy – G. D. Rai, Khanna Publishers
4) Energy Technology – Rao, Parulekar, Khanna Pulishers.

402045 : KINEMATIC ANALYSIS AND SYNTHESIS

Teaching Scheme :	**Examination Scheme :**
Lectures : 4 hrs. / week	Paper : 100 marks

UNIT 1 Review of Introduction to Mechanisms & Basic Concepts : Geometry of motion, plane and space mechanisms, terminology, definitions and assumptions. , planar and spatial mechanisms, kinematic pairs, Relative motion, degree of freedom for spatial mechanisms, kinematic inversions, mechanical advantage, transmission angle. equivalent mechanisms. Examples of various types of linkages and mechanisms in actual systems.

UNIT 2 Kinematic Analysis of Planar Mechanisms :
Position and displacement analysis - position of a point, graphical and complex-algebra method for displacement. Rotational and translation displacement. Velocity analysis - relative motion, linear and angular velocity, (Brief review). Freudenstein's theorem, velocity analysis and acceleration analysis - using normal acceleration, auxiliary point method, Goodman's indirect method (Only descriptive treatment). Computer-aided kinematic analysis. Features and Use of Mechanism simulation and analysis software packages like Working Model, ADAMS, or any similar mechanism modelling software.

UNIT 3 Curvature theory :
Fixed and moving centrodes, oscullating circles, - velocity and acceleration, inflection points and inflection circle. Euler - Savary equation, Bobillier's theorem, Hartman's construction, return circle, cusp points, cubic of stationary curvature, Ball's point. Applications in dwell mechanism.

UNIT 4 Kinematic Synthesis of planar mechanisms :
Type, number and dimensional synthesis, function generation, path generation and rigid body guidance problems, accuracy (precision) points, Chebychev spacing, types of errors, Graphical synthesis for function generation and rigid body guidance with two, three and four accuracy points using pole method, centre and circle point curves, Branch and order defects, synthesis for path generation.

UNIT 5 Analytical synthesis of four-bar and slider-crank mechanisms:

Freudenstein's equation, synthesis for four and five accuracy points, compatibility condition, synthesis of four-bar for prescribed angular velocities and accelerations using complex numbers.

Introduction to Coupler Curves :
Equation of coupler curve, Robert-Chebychev theorem, double points and symmetry. (Introductory Approach Only)

UNIT 6 Kinematic Analysis of Spatial Mechanisms :
Position, velocity and acceleration analysis of RGGR mechanisms, Eulerian angles theorem on angular velocities & acceleration, Denavit-Hartenberg parameters, Transformation matrix method of analysis of spatial mechanisms. application of special mechanism to robotics. Kinematic analysis of an industrial robot (Introductory treatment).

REFERENCES

1. Theory of Machines and Mechanisms, A. Ghosh and A.K. Mallik, Affiliated East-West Press - 1998
2. Kinematic Synthesis of Linkages, R.S. Hartenberg and J. Denavit, McGraw-Hill.1964.
3. Theory of Machines and Mechanisms, J.J. Uicker ,G.R.Pennock , J.E. Shigley Oxford Univ. Press, 2003.
4. Theory of Machines, S.S. Rattan, Tata McGraw Hill, 1993.
5. Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms and Machines , Robert L. Norton, McGraw Hill. 2002
6. Machines & Mechanisms Applied Kinematics Analysis : Myszka D H. , Pearson Education New Delhi, 2002.
7. Kinematic Analysis and synthesis of Mechanisms : A.K.Mallik , A. Ghosh and G. Dittrich – CRC Press 1994 .

B. E. Mechanical elective – Semester – I (2003 pattern)

402045 OPERATION RESEARCH

Teaching-4Hrs/week Theory- 100 Marks

Unit-I
Introduction to operation research and its History. Management application of application research. Mathematical models in operation research. Linear programming –introduction formulation, graphical solution, representation in standard form, simplex methods, big Method, duality and sensitivity analysis.

Unit- II
Transportation problem – Introduction formulation basic method of solving transportation problem, optimization methods like UV methods and stepping stone methods. Transship methods as an extension of transportation. Assignment problem, Hungarian methods to solve assignment problem. Traveling salesman as an extension of assignment problem.

Unit – III

(a) Inventory model: Introduction cost involved in inventory problems terminology, concepts of E.O, Q. in various deterministic models and simple probabilistic model such as instantaneous demand without set up cost.

(b) Introduction to non-linear programming, integer programming, dynamic programming

Unit- IV

(a) Game theory : Introduction, Minimax and Maximin Principle, solution of game with saddle point solution by dominance solution by graphical method, m x n size game problem, L.P. method, approximation method

(b) Replacement analysis: Replacement of capital equipment that deteriorates with time, value remains the same during the period and it changes with constant rate during the period, replacement of items that fail completely.

Unit – V

Queuing theory and sequencing problem: Introduction to queuing theory basis structure terminology and applications. Queuing models M/M/1: ∞/FEFO, M/M/S: ∞/FIFO, cost service rate, Sequencing of 2/3 jobs through N machines, simulation-Monte Carlo simulation.

Unit –VI

Network analysis : Introduction bar and milestone charts fundamentals of PERT and CPM Networks, Fulkerson's Rule time estimates in PERT and CPM critical path, probability of project completion in schedule time types of slack and float.

Reference Books:

1. Taha H., Operations Research, Prentice Hall of India Pvt. Ltd
2. Hira and Gupta, Operations Research
3. Srinath L. S. Pert and CPM
4. Sharma S.D., Operation Research, Kedarnath Ramnath and Co.
5. Basu S. K, Operation Research, IBH
6. Askhedkar Kulkarni, Operation Research, Dhanpat Rai & Sons.

402045 : Costing and Cost Control

Lecture Scheme: [Hours / week] Marking Scheme
Lectures: 4 Hours/week Paper: 100 Marks

1. **Introduction**: Significance for Engineers. Limitations of Financial Accounting, Corporate Objective – profitability. Elements of Cost – Material, Labor, Equipment, Overheads.
2. **Cost Classification**: Direct – Indirect, Variable – Fixed, Controllable – Uncontrollable, Overhead classification.
3. **Overheads** – Allocation, Apportionment. Basis for Overhead Apportionment, Budgets and budgetary Control.
4. **Joint products and by-products** : Segregation of the joint expenses. Process Costing – Transfer Cost.
5. **Cost-Volume Profit Relationship**: Assumptions. Break-even Point Concept. Contribution. Application in decision making.
6. **Special Techniques**: Standard Costing, Marginal Costing, Activity Based Costing.

Reference:

1. C. B. Gupta: Fundamentals of Business Accounting, Sultan Chand & Co.,

2. Samualson P. A. Economics, McGraw Hill International,
3. Bhar B. K., Costing
4. Prasad N. K., Cost Accounting, Book Syndicate Pvt. Ltd.,
5. Collin Durry, Management and Cost Accounting, English Language Book Society, London.

402046 : PROJECT WORK

Teaching Scheme:	Examination Scheme:
Practical : 2Hrs/week in Part I	TW : 100marks.
Practical : 6Hrs /week in Part II	Oral : 50 marks.

Fabrication of models, machines, prototypes based on new ideas, robots and machines based on hitech systems. Experimental set ups, energy audit/conservation studies of a department or a section in an organisation / plant. Fabrication of testing equipment. Renovation of machines, etc.

Above work to be taken up individually or in groups. The group shall not be more than 4 students.

A detailed report on the work done shall include project specifications, design procedure, drawings, process sheets, assembly procedure, test results, costing etc.

Guidelines for project report :

a) Report shall be typed or printed.
b) Figures and tables shall be on separate pages and attached at respective positions.
c) Project title and approval sheets shall be attached at the beginning of the report followed by index and synopsis of the project.
d) References shall be mentioned at the end followed by appendices (if any).
e) When a group of students is doing a project, names of all the students shall be included on every certified report copy.
f) Each group of students shall submit two copies of reports to the institute and one copy for each individual student.
g) In case of sponsored projects, the students shall obtain certificate from sponsor and attach it to the report.

OR

Computer based design/analysis or modelling/simulation of product(s) mechanism(s) or system(s) and its validation or comparison with available bench marks / results.

Oral shall be based on the project done by the students, jointly conducted by an internal and an external examiners appointed, at the end of Part II.

B.E.(MECH) SYLLYBUS TERM –II

402046 : PROJECT WORK

Teaching Scheme:	Examination Scheme:
Practical : 2Hrs/week in Part I	TW : 100marks.
Practical : 6Hrs /week in Part II	Oral : 50 marks.

Fabrication of models, machines, prototypes based on new ideas, robots and machines based on hitech systems. Experimental set ups, energy audit/conservation studies of a department or a section in an organisation / plant. Fabrication of testing equipment. Renovation of machines, etc.

Above work to be taken up individually or in groups. The group shall not be more than 4 students.

A detailed report on the work done shall include project specifications, design procedure, drawings, process sheets, assembly procedure, test results, costing etc.

Guidelines for project report :

a) Report shall be typed or printed.
b) Figures and tables shall be on separate pages and attached at respective positions.
c) Project title and approval sheets shall be attached at the beginning of the report followed by index and synopsis of the project.
d) References shall be mentioned at the end followed by appendices (if any).

e) When a group of students is doing a project, names of all the students shall be included on every certified report copy.
f) Each group of students shall submit two copies of reports to the institute and one copy for each individual student.
g) In case of sponsored projects, the students shall obtain certificate from sponsor and attach it to the report.

OR

Computer based design/analysis or modelling/simulation of product(s) mechanism(s) or system(s) and its validation or comparison with available bench marks / results.

Oral shall be based on the project done by the students, jointly conducted by an internal and an external examiners appointed, at the end of Part II.

402047 : CAD / CAM AND AUTOMATION

Teaching Scheme	**Examination Scheme**
Lectures: 4Hrs/Week	Paper : 100 Marks
Practicals : 2 Hrs/Week	Term Work : 25 Marks

Oral : 50 Marks

Unit: 1 COMPUTER GRAPHICS:

Transformation-Introduction, Formulation, Translation, Rotation, Scaling, Reflection, Homogenous Representation, Concatenated Transformation, Mapping of Geometric Models, Inverse Transformations, Projections :- Orthographic, Isometric, Perspective.

Unit: 2 MODELLING :

Curves:-Introduction, Analytic Curves, Line, Circle, Parabolas, Hyperbolas, Ellipses, Conics, Synthetic Curves, Hermite Cubic Spline, Bezier Curve, B-Spline Curve

Surfaces:-Introduction, Surface Representation, Analytic Surfaces, Synthetic Surfaces, Hermite bicubic Surface, Bezier surfaces, B-spline Surfaces, Coons Surface.

Solids: Introduction, Geometry &Topology, Solid Representation , Boundary Representation, Constructive Solid Geometry, Sweeps, Solid Manipulations, Feature Based Modelling.

Unit: 3 FINITE ELEMENT ANALYSIS

Introduction, Stress & Equilibrium, Boundary Condition, Strain - Displacement Relations, Stress-Strain Relation, Temperature Effects ,
Potential Energy & Equilibrium: - Rayleigh-Ritz Method, Galerkin's Method.

One Dimensional Problem: Finite Element Modelling, Coordinate and Shape function, Potential Energy Approach, Galerking Approach, Assembly of Global Stiffness Matrix & Load Vector, Properties of Stiffness Matrix , Finite Element Equations, Quadratic Shape Function, Temperature Effects .

Trusses: Introduction, Plane Trusses, Assembly of Global Stiffness Matrix for Banded Skyline Solutions.

Unit IV Two-Dimensional Problem Using Constant Strain Triangles.-
Introduction, Finite Element Modelling, Constant Strain Triangle, Problem Modelling & Boundary Conditions.

Two Dimensional Isoparametric Elements and Numerical Integration:
Introduction, Four Node Quadrilateral, Numerical Integration, Higher Order Elements.

Unit V COMPUTER AIDED MANUFACTURING

Introduction, Integrating CAD, NC & CAM, Preparing CAD data for NC, Machine Tools–Description of Machine Tools, Motions & Axes of Machine Tools, Point-to-Point and Continuous Path Machining, NC, CNC & DNC.
NC Programming –Machine Tool Coordinate System, Machine Zero, Job Zero, Cutter Programming, Tool offsets, Programming Steps, NC Programming Languages, G-codes & M-codes.

Unit VI AUTOMATION

Concepts of Automation, Types of Automation, Computer Integrated Manufacturing, Advantages and Limitations of Automation ,Automation Strategies in Manufacturing Industries, Flexible Manufacturing System (FMS), Types of FMS, Machining Centres.

ROBOT TECHNOLOGY

Joints, Drives to Actuate the Joints, Controller, Types of end effectors – mechanical, magnetic, pneumatic etc., Industrial Applications of Robot-Loading & Unloading of Machines, Spot Welding, Spray Painting, Assembly, Arc Welding, Inspection, Die -Casting & Forging Operations etc.

Classification & Structure of Robotic Systems - Point-to-Point Robotic Systems, Continuous Path Robotic System. Configurations of Robotic Arms such as Cartesian Robots, Cylindrical Coordinate Robots, Spherical Coordinate Robots, Articulated Robots, SCARA Robot

Introduction to Robot Programming- Manual Teaching, Lead –Through Teaching, Programming Languages.

Term Work

The term work shall consist of record of six assignments of problems based on the following topics:

1. Assembly of solid model of any one Mechanical system (containing 2 to 3 elements) like Coupling, Knuckle Joint, Cotter Joint, etc… using software Package. & Calculation of mass property.
2. Stress and deflection analysis of two dimensional truss using finite element package.
3. Stress and deflection analysis of any Mechanical component consisting of 2-D or 3-D elements using finite element package.
4. Programming and Manufacturing of one job on CNC lathe or CNC Milling machine.
5. Part programming of one job using CAM software.
6. Demonstration on any one industrial robot or Industrial visit to automation plant .

Reference Books

1. Ibrahim Zeid – 'CAD/CAM - theory and practice' Tata McGraw Hill Publishing Co.
2. Ibrahim Zeid – 'CAD/CAM - Mastering ' Tata McGraw Hill Publishing Co.
3. Chandrupatla T.R. and Belegunda A.D. – 'Introduction to finite elements in engineering' – Prentice Hall of India.
4. Segerling L.J. – 'Applied finite elements analysis' John Wiley and Sons.
5. Rao P.N., Introduction to CAD/CAM Tata McGraw Hill Publishing Co.
6. Groover M.P.- 'Automation, production systems and computer integrated manufacturing' – Prentice Hall of India
7. Yoram Koren - Robotics McGraw Hill Publishing Co.

Power Plant Engg. (402048)

Teaching Scheme	Examination Scheme
Lectures : 4 Hrs/Week	Paper : 100 Marks
Practicals : 2 Hrs/Week	T/W : 25 Marks
	Oral : 50 Marks

Unit I

Power Plants: Factors affecting Selection of site , Schematic Diagrams and relative merits of Steam ,Gas Diesel ,Hydro Power Plants, Present status of Power generation in India.

Nuclear Power Plants

Classification , Site Selection ,Types of Various Reactors with working of various Components. Nuclear Power plants In India. Waste Disposal

Unit II

Fuels for thermal power plants

Coal – basic ingredients & effect on furnace design coal beneficiation, blending, selection for thermal power plants, Liquid fuels, Gaseous fuels, slurry or emulsion type fuels, Handling , storage preparation & feeding, burning of fuels, Ash handling & dust collection, Draught system, Principle of Fluidized bed combustion.

Unit III

High Pressure Boilers

High pressure boilers, types of fluidized bed boilers (CFBCB, PFBCB) Steam piping and layout

Improved Rankine Cycle

Rankine Cycle With Reheating and Regeneration. Steam Power Plants with Process Heating.

Unit IV

Steam Nozzles : Flow of fluids through nozzle, subsonic, supersonic nozzles, and diffusers, continuity equation, variation of velocity, area and specific volume, mass of discharge through nozzle, maximum discharge and critical pressure ratio, chocking of nozzle, effect of friction, nozzle efficiency, velocity coefficient, , supersaturated flow,

Condensers : Necessity of condensers, types of condensers, Dalton's law of partial pressures, condenser vacuum and vacuum efficiency, condenser efficiency, air pumps, capacity of air extraction pumps, types of cooling towers, cooling water requirements.

Unit V

Steam Turbines : Types, constructional details, impulse turbine compounding of turbines, velocity diagrams(Single Stage Only), output , efficiency, effect of blade speed ratio on efficiency for impulse and reaction turbines, losses in turbines, reaction turbines – velocity diagrams (Single Stage Only), degree of reaction, reheat factor, stage efficiency, overall efficiency, constructional features of blades, governing of turbines, selection of turbines for various application, ,Labrynth Packing, & losses in turbines.

Unit VI

Economics Power Generation

Load curves, load duration curves, Connected load , maximum load , peak load, base load, and peak load power plants. load factor, plant capacity factor, plant use factor, demand factor, diversity factor. Performance at variable load of power plants, heat rate and incremental heat rate curves, load sharing among generators and prime movers, load shading between power stations, cost analysis, unit energy cost.

List of practicals : - Any 8 experiments.(Expt. No 1 is Compulsory)

1. Report based on visit to one Power plant thermal / Nuclear / combined cycle.
2. Study of high pressure boilers.
3. Study of fluidized bed combustion boilers.
4. Study of steam turbines – constructional details of impulse and reaction turbines.
5. Study of steam turbine systems – Speed governor, emergency trip gear, extraction pressure regulator.
6. Study of nuclear reactors.
7. Trail on steam turbine power plant to determine

a) Plant Efficiency , Rankine Efficiency Vs Load
b) Steam consumption and Specific Steam consumption Vs Load
c) Rate of Energy Input Vs Load
d) Heat Rate and Incremental heat Rate Vs Load

8. Trial on Diesel power plant to determine
   a) Plant Efficiency Vs Load
   b) Total fuel consumption Vs Load
   c) Rate of Energy Input Vs Load
   d) Heat Rate and Incremental heat Rate Vs Load
9. Study of power plant instrumentation.

Books

1. A Course in Power Plant Engg 5th Edition - Arora, & Domkundwar
2. Power Plant Engg - P K Nag
3. Power Plant Engg- G R Nagpal
4. Power Plant Engg- Mahesh Verma
5. Power Plant Engg - Keshwani
6. Thermal Engineering - P. L. Ballaney
7. Thermal Engineering-R. K. Rajput
8. Power Plant Engineering- El Vakil
9. Power Plant Engineering - P. C. Sharma

402049 : Industrial Fluid Power

Teaching Scheme	Examination Scheme
Lectures : 4 Hrs/week	Theory : 100 Marks
Practicals : 2 Hrs/week	Term Work: 25 Marks
	Oral : 50 Marks

UNIT 1 Introduction to Fluid Power

Fluid power system : Components, advantages, application in the fields of machine tools, material handling, hydraulic presses, mobile and stationary machines, clamping devices etc. Transmission of power at static and dynamic states. Types of hydraulic fluids, petroleum based, synthetic and water based. Properties of fluids, selection of fluids, additives, effect of temperature and pressure on hydraulic fluid. Seals, sealing materials, compatibility of seal with fluids. Types of pipes, hoses, material, quick acting couplings. Pressure drop in hoses/pipes. Fluid conditioning through filters, strainers, sources of contamination and contamination control. Heat exchangers.

UNIT 2 Source of Power

Pumps : Types, classification, principle of working and constructional details of vane pumps, gear pumps, radial and axial plunger pumps, screw pumps, power and efficiency calculations, characteristics curves, selection of pumps for hydraulic power transmission. Power units and accessories : Types of power units, reservoir assembly, constructional details, pressure switches, temperature switches, temperature switches.

Accumulators : Types, selection/design procedure, applications of accumulators.

UNIT 3 Fluid Power Control

Symbols for hydraulic and pneumatic circuits. Control of fluid power : (i) Necessity of fluid control through pressure control, directional control, flow control valves. (ii) Principle of pressure control valves, direct operated and pilot operated relief valves, pressure reducing valve, sequence valve. (iii) Principle of flow control valves, pressure compensated, temperature compensated flow control valves, meter in circuit, meter out circuits, flow through restrictor. (iv) Types of directional control valves : two way two position, four way three position, four

way two positions valves. Open centre, close centre, tandem centre valves. Cartridge valves. Manually operated, solenoid operated, pilot operated, direction control valves, check valve.

UNIT 4 Industrial Circuits

Actuators : (a) Linear and Rotary. (ii) Hydraulic motors- Types- Vane, gear, piston types, radial piston. (iii) Methods of control of acceleration, deceleration. (iv) Types of cylinders and mountings. (v) Calculation of piston velocity, thrust under static and dynamic applications, considering friction, inertia loads. (vi) Design considerations for cylinders.

Industrial circuits 1 - Simple reciprocating, Regenerative, Speed control(Meter in, meter out & bleed off), Sequencing, Synchronization, transverse & feed, circuit for rivetting machine, automatic reciprocating, fail safe circuit, counter balance circuit, actuator locking, circuit for hydraulic press, unloading circuit, motor breaking circuit.

UNIT 5 Pneumatics

Principle of Pneumatics : (i) Laws of compression, types of compressors, selection of compressors. (ii) Comparison of Pneumatics with Hydraulic power transmissions. (iii) Types of filters, regulators, lubricators, mufflers, dryers. (iv) Pressure regulating valves, (v) Direction control valves, two way, three way, four way valves. Solenoid operated valves, push button, lever control valves. (vi) Speed regulating – Methods used in Pneumatics. (vii) Pneumatic actuators-rotary, reciprocating.(viii) Air motors- radial piston, vane, axial piston (ix) Basic pneumatic circuit, selection of components(x) Application of pneumatics in low cost Automation and in industrial automation

UNIT 6 System Design

Design of hydraulic/pneumatic circuit for practical application, Selection of different components such as reservoir, various valves, actuators, filters, pumps based on design. (Students are advised to refer manufacturer's catalogues.).

List of experiments

Minimum of 8 experiments from the following; out of which 5 shall be from serial no. 1 to 9, two from serial no. 10 to 13 and one from 14 and 16. Record of experiments and assignments shall be submitted in the form of journal.

1. Study of vane/piston pumps and determination of performance characteristics. Study of cavitation and aeration phenomenon.
2. Study of Gear pump and determination of performance characteristics.
3. Study of pressure control valves and circuits using pressure control valves.
4. Study of flow control valves and circuits using flow control valves
5. Study of direction control valves and pilot operated check valves and circuits
6. Study of accumulators and charging procedure for accumulators.
7. Study of hydraulic power units and accessories.
8. Study of hydraulic systems for different applications
   (Such as steel mill, presses, injection moulding machines.)
9. Study of filters and determination of filtration ratings.
10. Study of compressed air generation and distribution systems.
11. Study of direction control valves used in pneumatics and circuits using manual and pilot operated valves.
12. Study of shuttle valve/Quick exhaust valve/twin pressure valve/pneumatic clamp
13. Study of electro-pneumatic valves and circuits.
14. Study of simple hydraulic systems used in practice such as copy turning attachment, hydraulic clamps, jack, dumper, forklift etc.
15. Testing of relief valve/flow control valve/direction control valve/hydraulic motor

16. Testing of double acting hydraulic cylinders

Assignment

One design report of a hydraulic or pneumatic system using manufacturer's catalogue.

Text/Reference Books

1. Pinches – 'Industrial Fluid Power', Prentice hall
2. D.A.Pease – 'Basic Fluid Power', Prentice hall
3. J.J.Pipenger – 'Industrial Hydraulics', McGraw Hill
4. H.L.Stewart – 'Hydraulics and Pneumatics', Industrial Press
5. A. Esposito – 'Fluid Power with application', Prentice hall
6. B. Lall – 'Oil Hydraulics', International Literature Association
7. Yeaple – 'Fluid Power Design Handbook'
8. Vickers Manual on Industrial Hydraulics
9. Festo's Manual on Pneumatic Principle, applications
10. ISO – 1219, Fluid Systems and components, Graphic Symbols
11. Majumadar, "Oil Hydraulics- Principle & Maintenance", Tata McGraw Hill

402050 : ROBOTICS

Teaching Scheme
Lectures : 4 Hrs/Week

Examination Scheme
Paper : 100 Marks

1. **Introduction to Robotics** : Automation and Robotics, Robot-Anatomy, Structure and classification, Continuous path & point to point robots, PUMA, SCARA, STANFORD Manipulators, Robot performance – Resolution, Accuracy and Repeatability, Homogeneous transforms, D-H parameters, Euler angles.

2. **Kinematics & Dynamics :**
   Direct kinematics of a manipulator, workspace.
   Inverse kinematics – Existance of inverse kinematic solution, Number of solutions, Geometric & Algebraic approaches to inverse kinematics, Inverse kinematics of PUMA manipulator.
   Dynamics : Lagrange – Euler formulation of dynamic equations of a manipulator.

3. **Trajectory Planning and Manipulator Control :**
   Introduction to Trajectory Planning, Considerations in path description / generation, joint space schemes, Cartesian space schemes, geometrical problems with Cartesian space schemes.
   Manipulator Control – Linear control of manipulators, 2^{nd} order control systems, control law partitioning, Trajectory following control, disturbance rejection, modeling and control of a single joint, introduction to force control.
   The control problem for manipulators, industrial robot control systems.

4. **End effectors, sensors and vision systems :**
   End Effectors – Types of end effectors, mechanical grippers, vacuum / magnetic / adhesive grippers, tools as end effectors, Gripper selection and design.
   Introduction to Sensors : Need of sensors in a robotic system, Robotic seonsors – Functional classification, status / environmental / Quality Ccntrol / Safety / workcell control sensors, types of sensors based on working principle, desirable features of sensors, various sensing devices

used in robot workcells , sensor characteristics, selection of sensors, photosensors, limit switches. Range sensors , proximity sensors, touch / sensors, Remote Center Compliance (RCC) device.
Vision Systems : Need of vision in a robotic system.

5. Robotic System design and applications

- Correlation between the robot design and the task to be performed, Manipulator Mechanism design , task requirements and manipulator design, kinematic configuration, redundant & closed chain structures, Actuation schemes, stiffness and deflections, position and force sensing.
Robot applications in material handling , machine loading / unloading , assembly , inspection and processing.

6. Robot Operation :

Actuators- characteristics and comparison of actuating systems, hydraulic , pneumatic and electrical actuators.
Robot programming, lead through programming, motion interpolation, branching, Robot languages, structure, WAIT, DELAY, SIGNAL commands, motion, end effector & sensor commands, subroutines

Reference Books :

1. "Introduction to Robotics – Mechanics and Control", John J. Craig, Pearson Education Inc., Second edition 1989 (Units 1,2,3,5)
2. "Industrial Robotics - Technology, Programming and Applications" M.P.Groover, M.Weiss,R.N.Nagel, N.G.Odrey, , McGraw Hill Book Co., 1986 (Units 1,4,5,6)
3. "Robotics - Control , Sensing, Vision and Intelligence" , K.S.Fu, R.C.Gonzalez, C.S.G.Lee, McGraw Hill Book Co. 1987 (Units 1,2,3,4)
4. 'Robot Design Handbook", G. B. Andeen (Unit 5)
5. "Industrial Robotics", Bernard Hodges, Jaico Publishing House , Second edition 1993 (Units 1,4,5,6)
6. "Introduction to Robotics – Analysis , Systems and Applications", Saeed Niku , Prentice Hall of India 2003.
7. "Robotics and Control ", R.K.Mittal and I.J.Nagrath, Tata McGraw Hill Publishing Company 2003.

Computational Fluid Dynamics 402050 B

Teaching Scheme: Theory Exam :
Lectures 4 hrs/wk 100 marks

Unit 1:

Introduction to CFD, Impact of CFD with examples, Flow Modelling using Control Volume – Finite and Infinitesimal Control Volumes, Concept of Substantial Derivative, divergence of velocity, Basic governing equations in integral and Differential forms – conservation of mass, momentum and energy. Iterative methods for matrix inversion, direct methods for banded matrices, Conjugate gradient and pre-conditioned conjugate gradient algorithms.

Unit 2 :

Numerical solutions of Ordinary differential equations – Runge Kutta methods, Simultaneous first order initial value problem, adaptive stepping, extrapolation, Implicit and semi-implicit methods, The shooting method for 2-point boundary Value problem – Blasius Solution (Boundary layer flow over a flat plate).

Unit 3:

Finite Difference – Discretization, consistency, explicit and implicit methods,

Errors and stability analysis, first order wave equation, stability of hyperbolic and parabolic equations, fundamentals of fluid flow modeling, the upwind scheme, artificial Viscosity

Unit 4:
Heat conduction in 1 and 2 dimensions - steady state and transient with explicit, implicit and semi-implicit Schemes: Algorithm/Flow Chart for 2 dim transient case. Finite difference applications in convective heat transfer, Thermally developing Flow inside a 2-dimensional channel and a circular pipe. Algorithm for this application

Unit 5:
MacCormack Method and its application to compressible flows, stability
Criterion, Quasi 1-dim flow: CFD solution of subsonic-supersonic isentropic nozzleflow Using MacCormack's technique, extension to general 2-dimensional flows.

Unit 6:
Solution of Navier-Stokes equations for incompressible flows using
MAC and SIMPLE algorithms : Staggered grid, MAC formulation, stability
Considerations, SIMPLE formulation, Formulation of the Flow problem with the SIMPLE algorithm, Introduction to the Finite Volume Method.

Reference Books

1. Computational Fluid Flow and Heat Transfer, K Muralidhar and T Sundararajan, Narosa Publishing House.
2. Computational Fluid Dynamics: The Basics with Applications, John D. Anderson Jr., McGraw Hill.
3. Computational Fluid Dynamics, T .J. Chung, Cambridge University Press.
4. Numerical Computation of Internal and External Flows, Vols I and II, Charles Hirsch, Wiley.

402045 : ENERGY MANAGEMENT

Teaching scheme
Lecturers: 4 Hrs/ Week

Examination
Theory paper: 100 Marks
Paper Duration: 3 Hrs.

Unit 1
Introduction : Energy crisis, finite fossil reserves, energy and environment, need for renewables and energy efficiency, need and importance of energy conservation and management.
Energy consumption patterns in Global and Indian industry, agriculture, commercial and residential sectors.
Energy conservation opportunities in different sectors with emphasis on Indian industry.
(6)

Unit 2
Energy Auditing - methodology, analysis and reporting. Portable and on-line instruments used for energy auditing.
Methods of financial analysis :
1) Simple payback period
2) Time value of money (future value, net present value)
3) Return on investment (ROI)
4) Internal rate of return (IRR) **(8)**

Unit 3
Costing of utilities : Determination of cost of steam, compress air and electricity. Energy conservation in refrigeration and air conditioning system, compressed air system.
Energy conservation in steam generation and supply system. Boiler performance, Boiler efficiency (direct and indirect method), excess air, flue-gas monitoring.
Steam distribution – various types of steam straps and their sizing and selection.
Condensate recovery system including flash steam utilisation. **(8)**

Unit 4
Insulation : Materials of insulations, form of insulations, desirable properties of insulations, economic thickness of insulation.
Refractories : Types, characteristics, examples, waste selection, application.
Electrical systems : Demand side management, energy conservation in motors, energy efficient motors, power factor improvement, energy efficient lighting, variable speed drive.
Lighting : Illumination levels, fixtures, timers, energy-efficient illumination.
(8)

Unit 5
Co-generation and waste heat recovery : different cogeneration systems and their selection, overall cogeneration efficiency, heat to power ratio, different waste heat recovery system. Energy conservation in pumps, performance evaluation, efficient system operations, flow control strategies and energy conservation opportunities. **(8)**

Unit 6
Energy conservation in compressed air systems, refrigeration and air-conditioning systems and water systems. Elementary coverage of energy conservation in pumps and fans. Thermal power plants. **(7)**

Recommended Books

1. P.H. Henderson : India - The Energy Sector, Oxford University Press.
2. Albert Thumann : Plant Engineers and Managers Guide to Energy Conservation.
3. D.A. Ray : Industrial Energy Conservation, Pergamon Press.
4. Callaghan : Energy Conservation.
5. IGC Dryden, editor : The Efficient use of Energy (Butterworths).
6. W.S. Turner, Editor : Energy Management Handbook (Wiley).
7. Patrick Steven R., Patric Dale R., Fordo Stephen : Energy Conservation Guide Book, The Fairmont Press Inc.
8. Energy Conservation - related booklets published by National Productivity Council (NPC) and Petroleum Conservation Research Association (PCRA).
9. F. William Payne and Richard E. Thompson : Efficient Boiler Operation Source Book.

402050 RAPID PROTOTYPING

Teaching Scheme **Examination Scheme**
Lectures: 4Hrs/Week Paper : 100 Marks

UNIT(I) Rapid Product Development
Product Development: Classical steps of Product Development, Requirement of New Product Development Strategies, Critical Factors Affecting Success, The Principle of Simultaneous Engineering

Model: Model Classes, Influence of Models to speed up Product Development
Model Making by Rapid Prototyping: Definitions of Rapid Prototyping (RP), Rapid Tooling (RT), Rapid Manufacturing (RM). Relating Rapid Prototyping models to Product Development Phases.

UNIT(II) Generation of Layer Information
Generation of Mathematical Layer Information: Description of the Geometry by a 3D data Record, Data Flow, CAD Model Types, Generation of Layer Information on Single Layer, The STL file format, The SLC file format. Projection of Geometrical Layer Information on the layer.

UNIT(III) Rapid Prototyping Technologies:
Photopolymerization – Stereolithography (SL), Laser Sintering, Layer Laminate Manufacturing (LLM), Extrusion Processes, Three Dimensional Printing (3DP) , Comparison & Evaluation of Rapid Prototyping processes.

UNIT(IV) Rapid Prototyping Materials:
Photopolymers, SL Resins, Sintering Materials, FDM Materials, LOM Materials, Model Makers Materials & their Physical, Mechanical, Thermal, Electrical properties.

UNIT(V) Rapid Tooling
Principal ways to Metal Tools, Metal Tools based on Plastic Rapid Prototyping Models-Direct use of Stereolithography, Indirect use of Stereolithography. Metal Tools based on Plastic Rapid Prototyping Processes, Metal Tools based on Metal Rapid Prototyping Processes- Multi Component Metal Powder Laser Sintering ,Single Component Metal Powder Laser Sintering, Laser Generation.

UNIT(VI) Rapid Prototyping Industrial Applications , Economic Aspects & Future Rapid Prototyping Processes
Rapid Prototyping in Industrial Product Development, Rapid Prototyping for the evaluation of Calculating Methods, Rapid Tooling in Industrial Product development, Rapid Prototyping in Medicine, Art, Archeology, Architecture.
Economics - Strategic Aspects, Operative Aspects, Service, Make or Buy decision.
Future Trends - Trends in Material Development, Trends in Process development

Reference Books

1. Rapid Prototyping –by Andreas Gebhardt, Hanser Gardner Publication Inc. Cincinnati.
2. Fast Prototype Tools In : Rapid Protyping & Manufacturing – by Naber H., Macht M. , Geuer A. ,Society of Manufacturing Engineers ,Dearborn
3. Solid Free Form Manufacturing – Advanced Rapid Prototyping – by D. Kochan , Elsevier Science Publisher B.V.,New York.

411050 Reliability Engineering

Teaching Scheme:
Lecture : 4 Hrs / Week

Examination Scheme:
Paper: :100 Marks

Unit 1
Fundamental concepts – reliability, quality, maintainability, availaibility, failure, failure modes, causes of failure and unreliability, factor of safety and reliability.

Probability theory: Set theory, total probability theorem, bayes rule.

Unit 2
Reliability Mathematics: functions for descrete/continuous random variables, skewness coefficient, chebyshev inequality, probability distributions, central limit theorem, fitting distribution to experimental data.

Unit3
Component reliability models: Hazard function rate, conditional reliability, constant failure rate model, time dependent failure model, MTBF.
System reliability models: Systems with components in series, in parallel, non-series parallel systems.

Unit4
Modelling of geometry, material strength and loads Strength based reliability

Unit 5
Design of mechanical components and systems Reliability based optimum design.
Unit 6
Fault tree analysis, failure mode and effect analysis Reliability testing.

References:

1. Reliability Based Design- S.S.Rao;Mcgraw Hill Inc.
2. Introduction to Reliability Engineering : E.E. Lewis, John Wiley & Sons.
3. Introduction to Reliability & Maintenability Engineering : Charles E. Ebeling, McGraw Hill.
4. Failure Mode & Effect Analysis- D.H.Stamatis – Productivity Press India Ltd.
5. Reliability Engineering – Dr. S.K. Basu

Automobile Engineering(402050)

Teaching scheme :
Lectures : 4 hrs / week

Examination scheme :
Theory : 100 marks

Unit I: Basic Concepts and Clutches 8 hrs.
Vehicle specifications, classification, layout, applications, purpose of clutch, classification, single plate clutch, multiple plate clutch, centrifugal clutch, cone clutch, diaphragm spring clutch, vacuum operated clutch, clutch plate, lining material

Unit II: Gearbox 8 hrs.
Function, various resistances, tractive effort, performance curves, power required for acceleration and gradiability, selection of gear ratio, sliding mesh, gear box, constant mesh gear box and synchromesh gearbox, epycyclic gear box, torque convertor, automatic transmission, overdrive.

Unit III: Suspension Systems 8 hrs.
Object, various types of springs, shock absorbers, sprung weight and unsprung weight, conventional suspension system, independent suspension systems, air suspension, hydra-gas suspension, rubber suspension, interconnected suspension, self leveling suspension.

Unit IV: Front Axle, Steering System and Tyres 8 hrs.

Purpose, requirement, wheel alignment and wheel balancing, centre point steeing, cornering force slip angle, scrub radius, steering characteristic,steering gearboxes, power steering.

Tyres – function, construction, types of tyres, tubeless tyres.

Unit V: Propeller Shaft, Universal joints, Differential and Rear Axle 8 hrs.

Propeller shaft, universal joints, final drive, differential and their types, rear axle arrangements, two speed rear axle, single, double and triple reduction rear axles

Unit VI: Braking Systems and Automotive Electricals 8 hrs.

Purpose, classification, mechanical, hydraulic, air brakes, servo-braking systems, antiskid braking systems.

Battery, ignition system, starting system, charging system, dashboard instruments.

Preventive maintenance, trouble shooting and diagnosis for all systems mentioned in from unit 1 to 6.

Reference books :

1. Newton, Steeds & Garrett, 'Motor vehicle', 'The English language book society'
2. Crouse W.H., 'Automotive Mechanics', Tata McGraw Hill Publishing Company.
3. Joseph Heitner, 'Automotive Mechanics', C.B.S.Publisher and Distributors.
4. Narang G.B.S., 'Automobile Engineering', S.Chand and Company Ltd.
5. Singh Kripal, 'Automobile Engineering', Vol.II., New Chand Jain.
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