

## **B. Tech. in MECHATRONICS ENGINEERING**

### **Syllabus of Paper – 1**

#### **MATERIAL SCIENCE & METALLURGY**

Structure of metal: Crystal structure (BCC, FCC and HCP, Packing factor and density calculation), X-ray diffraction, miller indices, lattices, imperfections, elementary treatment of point and line defects and their relation to mechanical properties. Diffusion: Diffusion mechanisms, steady state and non steady state diffusion, factors affecting diffusion Deformation: Slip, twinning, effect of cold and hot working on mechanical properties, principles of recovery, re-crystallization and grain growth. Fracture: Types of fracture ductile and brittle, fatigue. Creep: Basic consideration in the selection of material for high and low temperature service, creep curve, effect of material variables on creep properties, brittle failure at low temperature. Solidification: Phases in metal system, lever rule, solidification of metal and alloys, solid solution, eutectic, eutectoid and inter-metallic compounds, Iron carbon equilibrium diagram, TTT-diagram. Effect of alloying elements on TTT diagram, S-N curve. Heat Treatment: Principles and purpose of heat treatment of plain carbon steels, annealing, normalizing, hardening, tempering, isothermal treatment, case hardening – carburizing, nitriding etc, precipitating hardening of aluminum alloys. Hardenability: determination of hardenability Jominy end quench test. Materials: Plain Carbon steels, effect of alloying elements, properties, uses, springs, and wear resisting steels, IS standards codes for steels. Corrosion: Types of corrosion, Galvanic cell, rusting of Iron, Methods of protection from corrosion. Fiber Reinforced Composites: General characteristics, Applications, Introduction to Fibers – glass, carbon, Kevlar 49 fibers. Matrix – Polymeric, Metallic, Ceramic Matrix, Coupling agents and fillers.

#### **FLUID MECHANICS**

Fundamental Concepts of Fluid Flow: Fundamental definitions, Fluid properties, classification of fluids, Flow characteristics, Foundations of flow analysis, Incompressible and compressible fluids, one, two and three dimensional flows. Pressure and its measurements: Pascal's law, pressure variation in a fluid at rest, Classification of different manometers. Fluid Statics: Fluid pressure, Forces on solid surfaces, Buoyant forces, Metacentre and Metacentric height. Stability of floating bodies. Kinematics of Fluid Flow: Types of fluid flow, streamline, path line and streak line; continuity equation, Equations for acceleration, Irrotational and rotational flow, velocity potential and stream function, Vortex flow, Continuity equation. Dynamics of Fluid Flow: Control volume analysis, Euler's equation of motion, Bernoulli's equation, Bernoulli's theorems from steady flow energy equation, Venturi meter; Pitot tube, Momentum equation. Laminar Flow: Reynold's experiment, Critical velocity, Steady laminar flow through a circular tube, Measurement of viscosity. Turbulent Flow: Shear stress in turbulent flow. Hydrodynamically smooth & rough boundaries. Velocity distribution for turbulent flow in smooth and rough pipes. Boundary Layer Flow: Boundary Layer Theory and Applications: Boundary Layer thickness, displacement, momentum and energy thickness, Flow separation, Drag and lift on immersed bodies. Pipe Flow Systems: Darcy-Weisbach equation, Moody diagram, Energy losses in pipelines, concept of equivalent length, Flow between two reservoirs multiple pipe systems. Siphon. Dimensional Analysis and Principles of Similarity: Buckingham's Theorem and its applications, Geometric, Kinematics and Dynamic similarity; Dimensionless numbers-Reynolds,

Froude, Euler, Mach, Weber Number and their significance. Flow Measurements: Measurement of flow using, orifice meter, nozzle, Measurement of flow in open channels -rectangular, triangular, trapezoidal weir, Cipolletti weir. Hot-wire anemometer.

## **MECHANICS OF SOLIDS**

Simple Stresses & strains: Concept of stress at a point, Tensile, Compressive, shear and volumetric stresses and strains, Young's modulus, modulus of rigidity, complementary shear stress, lateral strain and Poisson's ratio. Strain relationships. Compound bars and Temperature stresses: Stresses in compound bars carrying axial loads and subjected to temperature stresses. Simple bending: Shear force and bending moment diagrams of cantilevers, simply supported beams under concentrated, uniformly loaded and varying loads with and without overhangs. Stresses in beams and cantilevers under bending, beam of uniform strength, bending due to eccentric loads. Shear stress in beams, strain energy, Castigliano's theorem Slope and deflection of cantilevers and beams under concentrated and uniformly distributed loads. Moment Area method, Macaulay's method; principle of superposition. Columns: Combined direct and bending stresses in columns, Euler's and Rankine Gordon equations. Torsion: Stresses and strains in pure torsion of solid circular shafts and hollow circular shafts. Power transmitted by shafts; combined bending and torsion. Strain energy in torsion. Complex stresses and strains: Principle stress and strain due to combination of stresses, Mohr's circle, strain energy, theories of Failures. Springs: Close-coiled springs, leaf springs. Cylinders: Thin and thick cylinders, Lamé's Theorem, compound cylinders, spherical vessels.

## **KINEMATICS AND DYNAMICS OF MACHINERY**

General concepts, Velocity and Acceleration Analysis: Introduction of Simple mechanism, Different types of Kinematics pair, Grubler's rule for degree of freedom, Grashof's Criterion for mobility determination Inversions of 3R-P, 2R-2P chains, Kinematic analysis of planar mechanism Cams: Classification, Cams with uniform acceleration and retardation, SHM, Cycloidal motion, oscillating followers. Gyroscopes: Gyroscopic law, effect of gyroscopic couple on automobiles, ships, aircrafts. Dynamic Analysis: Slider-crank mechanism, Klein's construction, turning moment computations. Gears: Geometry of tooth profiles, Law of gearing, involute profile, cycloidal profile, interference, helical, spiral and worm gears, simple, compound gear trains. Epicyclic gear trains – Analysis by tabular and relative velocity method, fixing torque. Governors & Flywheel : Hartnell, Porter governors – construction and working, Flywheel. Balancing: Static and Dynamic balancing-balancing of revolving masses, single and multi-cylinder engines. Reciprocating masses – single cylinder engine. Vibrations: Vibration analysis of single degree of freedom, natural, damped forced vibrations, base-excited vibrations, and transmissibility ratio.

## **SIGNALS AND SYSTEMS**

Continuous And Discrete Time Signals: Definition of signal, Classification of Signals: Periodic and Aperiodic, Even and Odd, Energy and Power signals, Deterministic and Random signals. Singular Functions: Unit impulse, unit step, unit ramp, complex and exponential, parabolic, Signum, Sinc etc. Properties of unit impulse in continuous and discrete domain, properties of basic functions w.r.t. orthogonality. Transformation in independent variable of signals: Time scaling, Time shifting, Amplitude scaling. Representation of signals in terms of singular function and orthogonal functions. Systems: Definition of system, types of systems: Linear and nonlinear, static and dynamic, causal and

non-causal, time variant and invariant, invertible and non-invertible, stable and non-stable. System described by differential equation and difference equation. LTI System: Properties of LTI System, impulse response, convolution and its properties in continuous and discrete domain with proof. Linear convolution in continuous and discrete domain using graphical method, using general formula and matrix method. Fourier series: Need and application of Fourier series. Fourier series representation of continuous time and discrete time signals using exponential method and trigonometric method. Magnitude and Phase spectrum of signals. Fourier Transform: Properties of the Continuous time and discrete time Fourier Transform. Magnitude and Phase representations of frequency response of LTI systems Analysis and characterization of LTI systems using Differential Equations and Difference equation. Magnitude- Phase Representation of Frequency Response of LTI System: Linear phase, concept of phase delay and group delay. All pass system. Laplace Transform: Properties of Laplace transform, concept of ROC and its properties. Computation of impulse response & transfer function using Laplace transform. Inverse-Laplace transforms. Computation of impulse response, total response (zero state and zero input response) & transfer function using Laplace transform. Sampling: Sampling of low pass signals, ideal sampling, Aliasing effect, Nyquist rate, reconstruction of signal. Sampling of discrete time signals. Z Transform: Region of convergence – properties of ROC, Properties of Z-transform. Inverse Z-transform using contour integration - Residue theorem, Power series expansion and partial fraction expansion. Relationship between Z-transform, Fourier transform and Laplace transform. Computation of impulse response, total response (Zero state and Zero input response) & Transfer function using Z-Transform. Stability of discrete-time LTI System.

## **CONTROL SYSTEMS**

Control Systems: Introduction to basic terms, classifications & types of Control Systems, block diagrams & signal flow graphs. Transfer function, determination of transfer function using block diagram reduction techniques and Mason's Gain formula. Control system components: Electrical / Mechanical / Electronic / A.C. / D.C. Servo Motors, Stepper Motors, Tacho Generators, Synchros, Magnetic Amplifiers, Servo Amplifiers. Time – Domain Analysis : Time domain performance specifications, transient response of first & second order systems, steady state errors and static error constants in unity feedback control systems, response with P, PI and PID controllers, limitations of time domain analysis. Frequency Domain Analysis: Polar and inverse polar plots, frequency domain specifications and performance of LTI systems, Logarithmic plots (Bode plots), gain and phase margins, relative stability. Correlation with time domain performance closes loop frequency responses from open loop response. Limitations of frequency domain analysis, minimum/non-minimum phase systems. Stability & Compensation Techniques: Concepts, absolute, asymptotic, conditional and marginal stability, Routh-Hurwitz and Nyquist stability criterion, Root locus technique and its application. Concepts of compensation, series/parallel/ series-parallel/feedback compensation, Lag/Lead/Lag-Lead networks for compensation, compensation using P, PI, PID controllers.

## **THERMAL SCIENCE**

Basic concepts: Introduction to the Basic definitions of Engineering Thermodynamics. Thermodynamic systems : Closed, Open and Isolated systems. Microscopic and Macroscopic view. Intensive and Extensive properties. Zero<sup>th</sup> law of Thermodynamics. Phase, State, Process, Cycle. Point functions and Path functions. Gas Laws and Equation of State. Work and Heat. First Law of

Thermodynamics: Introduction to First Law of Thermodynamics, Internal energy. Non flow processes, p-v diagrams. Concept of Flow work, Enthalpy. Analysis of steady flow and unsteady flow processes and their applications. Throttling process. Second Law of Thermodynamics: Limitations of First law and necessity of Second Law of Thermodynamics, Kelvin Planck statement and Clausius statement, Reversible and Irreversible processes. Carnot cycle, Reversed Carnot cycle. Carnot's Theorem, Clausius inequality. Entropy, Change in Entropy during various processes and representations on t-s diagrams, Entropy principle, Entropy Generation. Availability and Irreversibility : High grade and low grade energy. Available and unavailable energy. Deadstate. Loss of available energy due to Heat transfer through a Finite temperature difference. Availability. Reversible work and Irreversibility. Availability in non flow systems and steady flow systems. Second law efficiency. Thermodynamic Property Relations: Maxwell Relations. Clapeyron Equation. Properties of a Pure Substance: Phase equilibrium of a pure substance on t-v diagram. Normal boiling point of a Pure substance. Saturation states. Compressed liquid. p-v & p-t diagram of a pure substance. Saturated steam, Dry and saturated steam, Superheated steam. Use of Steam tables and Mollier diagram. Different processes of vapour on p-v and t-s diagrams. Measurement of Dryness fraction. Vapour Power Cycles : Carnot cycle. Simple Rankine cycle. Effect of various parameters on the efficiency of Rankine cycle. Reheat and Regenerative cycles. Gas Power Cycles: Carnot cycle, Otto cycle, Diesel cycle, Dual cycle, Stirling cycle, and Ericsson cycle. Gas Turbines: Brayton cycle, Thermal refinements. Performance of Gas turbines, Combined cycle. Principles of Jet Propulsion. Turbojet and Turbo-prop engines, Rocket engines.

## **MANUFACTURING TECHNOLOGY**

Moulding: Introduction to sand moulding, Pattern design, Pattern layout and construction, testing of mouldings and. moulding and core making machines, CO<sub>2</sub> - Process, fluid sand process, shell moulding, cold curing process, hot-box method, flask less moulding, Design of metal moulds, Die Design for die Casting. Casting: Directional principles, Solidification, types of gating systems, Pouring time and temperature. Design criteria of pouring basin, sprue, runner, gate and riser, gating ratio- related numerical problems, Use of chaplet, chills and padding, Selection of melting furnaces, Crucible furnaces, Electric furnaces, Induction furnace, Control of melt and Cupola charge calculations. Foundry mechanization and layout. Welding: Principle, advantages, limitations and applications, Tungsten Inert Gas welding, Metal Inert Gas welding, Electro - slag welding, Electro - Gas Welding, Explosive Welding, Ultrasonic Welding, Electron Beam Welding, Laser Beam Welding, Friction Welding, Cold Welding, Thermit Welding. Welding Defects-causes and remedies. Numerical problems on electric arc welding and resistance welding. Metal Forming: Introduction to Metal Forming, Elastic & plastic deformation, Hot working and cold working. Work required for forging, Hand, Power, Drop forging. Analysis of wire drawing and maximum reduction. Tube drawing, Extrusion, types and its application. Rolling process, rolling mills & rolled-sections. Defects in metal forming processes. Sheet metal processes, shearing, calculation of punch force, shearing dies, stretch forming, Deep drawing and its analysis.

## **MEASUREMENTS AND INSTRUMENTATION**

Introduction to Measurement: Significance of measurement, Different methods of measurement, Classification of measuring instruments, Application of measurement systems, typical measurement schemes. Units and Standards: MKS, SI units of engineering parameters, Details of different

standards-mass, length, time, frequency, temperature, EMF, ampere, sub standards and lab standards. Performance Characteristics: Definition of range, span, accuracy, precision, drift, sensitivity, reproducibility, repeatability, dead zone, resolution, hysteresis, threshold, zero error, noise, linearity, loading effect, static characteristics. Testing & Calibration of measurement setup: Dynamic Characteristics: Dynamic response; Transient response; speed of response, fidelity, measuring lag etc, Linear approximation, Introduction to compensation techniques. Significance of testing and calibration, Calibration curve, Standards for calibration, Different calibration procedures-primary, secondary, direct, indirect, routine calibration, Calibration setup: pressure gauge, level etc. Calibration of Ammeter, Voltmeter and Wattmeter, Energy meter. Sensors and Transducers: Transducer classification, Active and Passive Transducers, Potentiometric Transducers, Linear and non-linear potentiometer, Resistance/Bonded Type Strain Gauge. Displacement Measurement: Linear/ Angular displacement, Pneumatic / Electric / Optical / Ultrasonic / Magnetostrictive / Electronic Displacement Transducers, Proximity Sensors, Typical application schemes. Pressure Measurement: Pressure Units, Force Summing Devices, Secondary Transducers, Vacuum Measurement, Torque Measurement, Tachogenerators. Temperature Measurement: Electric Method, Change in Electrical Properties, Thermoelectricity, Thermocouples, Thermistors, Thermowells. Flow Measurement: Reynold Number, Head type flowmeters, Velocity measurement type flowmeters, Massflow measurement type flow meters. Level Measurements: Importance, advantage and limitation of different instruments, visual level indicators, float type, Purge method of measuring level, Buoyancy method, Resistance and capacitance probes for level measurement, limit switches, level measurement in pressurized vessels, solid level measurement techniques, modern techniques for level measurements and their applications.

## **Syllabus of Paper - 2**

### **SENSORS AND TRANSDUCERS**

Introduction to Sensors: Definition and differences of sensors and transducers, Classification, static and dynamic characteristics, electrical characterization, mechanical and thermal characterization including bath-tub curve. Different Sensors: Mechanical & Electromechanical: Potentiometer, Strain gauges, Inductive sensors—Ferromagnetic type, Transformer type, Electromagnetic, Capacitive sensors—parallel plate, variable permittivity, electrostatic, piezoelectric, Introduction to PZT family. Thermal sensors: Gas thermometric sensors, Dielectric constant, refractive index thermo-sensors, nuclear thermometers, resistance change type thermometric sensors, Thermoemf sensors. Magnetic sensors: Basic working principles, Magnetostrictive, Hall effect, Eddy current type, SQUID sensors. Radiation sensors: Photo-detectors, Photo-emissive, photomultiplier, scintillation detectors. Electroanalytical sensors: Electrochemical cell, SHE, Polarization, Reference electrode, Metal electrodes, Membrane electrodes, Electroceramics. Advancement in Sensor technology: Introduction to smart sensors, Film sensors, Introduction to semiconductor IC technology and Micro Electro Mechanical System (MEMS), Nano-sensors. Bio-Sensors. Different Transducers: LVDT, RTD, Thermistor, Wire anemometer, piezoresistors, Variable diaphragm capacitance transducers, Angular movement transducers, seismic mass transducer, interferometer transducer. Feedback transducer system: Inverse transducer, Self-balancing transducer, Servo-operated manometer, Feedback pneumatic load cell, integrating servo.

### **HYDRAULICS AND PNEUMATICS**

Hydraulic Systems: Introduction to fluid power system, Advantage and Disadvantage of Fluid power, Hydraulic fluids- functions, fluid characteristics. Construction, operation, characteristics and graphical symbols of hydraulic components, Sources of hydraulic power, pump classification. Fluid power actuator, Fluid motors. Pneumatic Systems: Introduction, comparison of pneumatic/ hydraulic and electrical systems, characteristics & symbols of pneumatic components. Air Compression system, Air preparation – principles and components. Hydraulic Components & Hydraulic Circuits: Introduction, function of control elements, direction control valve, check valve, pressure control valve, pressure reducing valve, flow control valves, sequence valve, electrical control solenoid valves, Accumulators – types of accumulators, applications and accumulator circuits, intensifier – application and circuits. Pneumatic Components & Pneumatic Circuits: Pneumatic Components- Filter, regulators, lubricators, pneumatic actuators, quick exhaust valve, pressure sequence valve, time delay valve, solenoid valve, electrical limit switch, proximity switch, speed control circuits, cascade method- sequential circuit design, synchronizing circuits, time delay circuits. Application, failure and troubleshooting: Development of hydraulic / pneumatic circuits applied to machine tools, presses, material handling systems, automotive systems, packaging industries, manufacturing automation. Maintenance of fluid power systems – preventive and breakdown. Maintenance procedures. Trouble shooting of fluid power systems – fault finding process, equipments/tools used, causes and remedies. Safety aspects involved.

### **MACHINE ELEMENT DESIGN**

Introduction: Principles of mechanical design, systematic design process, aesthetic and ergonomic considerations in design, use of standards in design. Manufacturing consideration in

design, casting, machining, forging, Dynamic and fluctuating stresses, fatigue failure and endurance limit, stress concentration, causes and remedies in design. Factor of safety Tolerances and types of fits as per BIS Selection of materials, designation of steels .Design of Cotter and knuckle joints. Design of Elements: screwed fastenings, bolted and riveted joints under direct and eccentric loads, initialtightening loads in bolts. Welded joints, strength of welded joints, eccentrically loaded joints, welded joints subjected to bending moment and torsion. Translation screws: force analysis and design of various types of power screws,; screw jack, C- clamp, togglescrew jack. Shafts, keys and couplings –design of rigid and pin bushed flexible couplings. Levers design Springs, uses and design of close coiled helical springs shot peening of springs. Classification of Gears, spur gears, Lewis equation, subjected to dynamic and wear loads, gear failures. Bearings - types of sliding bearing, design of sliding bearing using McKee's equation; types of lubrication Types of Ball & Roller Bearings- selection of bearings from manufacturer's catalogue based on static & dynamic load carrying capacity, load-life relationships.

### **PROGRAMMABLE LOGIC CONTROLLER & SCADA**

Programmable Logic Controller (PLC) Basics: Introduction, Parts of PLC, Principles of operation, PLC sizeand applications, PLC Advantages and Disadvantages, PLC Manufacturers, PLC hardware components, I/O section, Analog I/O modules, Digital I/O modules, CPU- Processor memory module, Programming devices, Devices which can be connected to I/O modules, Relay, Contactor, SPST, Push Buttons, NO/NC Concept. Programming of Programmable Logic Controller: General PLC Programming Procedures, Contacts andCoils, Program SCAN, Programming Languages, Ladder Programming, Relay Instructions, Instruction Addressing, Concept of Latching, Branch Instructions, Contact and Coil I/O Programming Examples, Relation of Digital Gate Logic to Contact/Coil Logic. Programmable Logic controller Functions: Timer Instructions: ON DEAY Timer and OFF DELAY timer,Counter Instructions: UP/DOWN Counters, Timer and CounterApplications,Program Control Instructions:Master Control Reset, Jump and Subroutine,Math Instructions- ADD, SUB. Data Handling: Data Move, Data Compare, Data Selection, Electro-pneumatic Sequential Circuits and Applications. SCADA: Definition of SCADA, Applicable Processes, Elements of SCADA System, A Limited Two-WaySystem. Real Time Systems: Communication Access and Master-Slave determining scan interval. Introduction to Remote Control, Communications-A/D Conversion, Long Distance Communication, Communication System components in brief- Protocol, Modems, Synchronous/Asynchronous telephone cable/radio, Half Duplex, Full Duplex System, Brief introduction to RTU and MTU, Applications-Automatic Control, Advisory Applications.

### **AUTOMOTIVE ELECTRONICS**

Fundamentals Of Automotive Electronics: Introduction to Automobile Engineering, Basic automotive system, Electrical systems, Evolution of electronics in automotive, Automotive Control Systems, Components for Electronic Engine Management, Electronic management of chassis system, Current trends in Automobiles. Automotive Control System Applications Of Sensors And Actuators: Introduction, Basic sensor arrangement, Air flow rate sensor, Engine crankshaft angular position senor, Engine speed sensor, Timing sensor for ignition and fuel delivery, Throttle angle sensor, Pressure sensor, Temperature sensors, Exhaust gas oxygen sensors, Knock Sensor, Engine torque sensors, Automotive engine control actuators – Fuel injection, Exhaust gas recirculation actuator. Automotive Engine Control Systems: Engine Control Objectives, Spark Ignition Engines:Engine

control functions, Engine control modes, Fuel delivery systems, MPFI, Ignition Systems, Diagnostics – Compression Ignition Engines – Emission control. Automotive Transmission Control Systems : Transmission control, Cruise control system, Antilock braking system, Tire-slip controller, Traction control, Electronic Suspension system, Steering control, Stability control, Integrated engine control. Automotive Monitoring And Diagnostics: Electromagnetic Interference (EMI) Suppression, Electromagnetic Compatibility, Electronic Dashboard Instruments, Fundamentals of diagnostics, Diagnostics procedure and sequence, On board and off board Diagnostics in automotive, Security and warning Systems.

## **MICROPROCESSORS AND MICROCONTROLLERS**

Introduction to Microprocessor Systems: Architecture and PIN diagram of 8085, Timing Diagram, memory organization, Addressing modes, Interrupts. Assembly Language Programming. 8086 Microprocessor: 8086 Architecture, difference between 8085 and 8086 architecture, generation of physical address, PIN diagram of 8086, Minimum Mode and Maximum mode, Bus cycle, Memory Organization, Memory Interfacing, Addressing Modes, Assembler Directives, Instruction set of 8086, Assembly Language Programming, Hardware and Software Interrupts. Interfacing of 8086 with 8255, 8254/ 8253, 8251, 8259: Introduction, Generation of I/O Ports, Programmable Peripheral Interface (PPI)-Intel 8255, Sample-and-Hold Circuit and Multiplexer, Keyboard and Display Interface, Keyboard and Display Controller (8279), Programmable Interval timers (Intel 8253/8254), USART (8251), PIC (8259), DAC, ADC, LCD, Stepper Motor. Overview of Microcontroller 8051: Introduction to 8051 Micro-controller, Architecture, Memory organization, Special function registers, Port Operation, Memory Interfacing, I/O Interfacing, Programming 8051 resources, interrupts, Programmer's model of 8051, Operand types, Operand addressing, Data transfer instructions, Arithmetic instructions, Logic instructions, Control transfer instructions, Timer & Counter Programming, Interrupt Programming.

## **COMPUTER AIDED DESIGN**

CAD: CAD Hardware: Types of Systems, CAD Systems Evaluation Criteria, Input Devices, Output Devices; CAD Software: Standards, Basic Definitions – Data Structure, Database, DBMS, Database Coordinate System, Working Coordinate System, Screen Coordinate System, Modes of Operations, User Interface, Software Modules – OS Module, Applications Module, Programming Module, Communications Module, Modelling and Viewing. Mapping of Geometric Models: Translation, Rotational, General, Changes of Coordinate System. Three Dimensional Transformations: Point representations, Transformation Matrices, Scaling, Translation, Rotation, Reflection. Projections: Orthographic, Isometric, Perspective, Point at Infinity & Vanishing Point. Curves: Representation of Space Curves, Cubic Spline, Normalized Cubic Splines, Bezier Curves, B-spline Curves. Surface Generation: Plane Surfaces, Ruled Surfaces, Surface of Revolution, Sweep Surface, Bezier Surface, Cubic Surface Patch, B-Spline Surface, Composite Surface. Solid Modeling: Set Theory, Boolean Operations, B-rep Modeling, CSG, Sweep Representations, Spatial Occupancy Enumeration Numerical problems. Geometric Property Formulation: Curve Length, Surface Area, Volume Calculation, Mass Calculation, Centroid Calculation. CAD/CAM Data Exchange: Introduction, IGES, PDS, Finite Element Methods: General Method for FEM, Finite Element Analysis, an overview of CNC machines, Manual part programming:- preparatory, miscellaneous functions- Fanuc, Sinumeric, Hass controls. Linear interpolation, circular interpolation, canned cycles, cycles of threading &



grooving operations, tool compensation, sub-program, main program, part programming structure, work co-ordinate system, absolute & incremental commands, feed, program zero point, co-ordinate system, process planning & flow chart for part programming, scaling, rotating, mirroring, copy & special cycles for CNC lathe and milling.

## **MECHATRONICS SYSTEM DESIGN**

Introduction: Evolution of Mechatronics, origins, Multidisciplinary scenario. Signal Theory and Engineering Tools: Signal nomenclature, Signal analysis and processing, Multi domain signal representation, Analysis and representation of periodic analog signals, discrete fourier transforms and fast fourier transform, analysis of signal in time frequency domain, Differential equation, Laplace transform, difference equation, Z- transform, power and energy of the signal. Electrical components and Electronic devices::Introduction, Basics of electrical components, Basic of electronic devices. Basics of digital technology: Number system, Gray codes, DNS architecture, Boolean Algebra, Logic states, logic functions, universal gates, combinational and sequential logic circuits, flip flops, Karnaugh maps, TTL & CMOS. Introduction to signal conditioning: Signal Conditioning Processes, Inverting Amplifiers, Non Inverting Amplifiers, Summing, Integrating, Differential, Logarithmic Amplifiers, Comparators, Amplifiers Error, Filtering, Wheatstone Bridge, Temperature Compensation, Thermocouple Compensation, Modeling of Mechanical systems and Simulations. Electrical Actuation Systems: Switching Devices, Mechanical Switches – SPST, SPDT, DPDT, Debouncing keypads; Relays, Solid State Switches, Diodes, Thyristors, Transistors, Solenoid Type Devices: Solenoid Operated Hydraulic and Pneumatic Valves, Control of DC Motors, Permanent Magnet DC Motors, Brushless Permanent Magnet DC Motors, AC Motors and speed controls, Stepper Motors and Controls, Servo Motors. System Interfacing and data acquisition: Data acquisition systems, Data loggers, SCADA, Interfacing requirements, Buffers, Darlington Pair, Handshaking, Serial and Parallel Port Interfacing, Peripheral Interface Adapters, Analog to Digital Conversion, Digital To Analog Conversion, Sample and Hold Amplifiers, Multiplexers, Time Division Multiplexing, Digital Signal Processing, Pulse Modulation, Component Interconnection and Impedance Matching, Interfacing Motor drives. Electrical power supply and protection. Programmable logic controllers: Programmable logic controllers (PLC) Structure, Input / Output Processing, principles of operation, PLC versus computer, Programming Languages, programming using Ladder Diagrams, Logic Functions, Latching, Sequencing, Timers, Internal Relays And Counters, Shift Registers, Master and Jump Controls, Jumps, Data Movement, Code Conversion, Data handling and manipulation, selecting a PLC. Case Studies: Mechatronic approach to design, Boat Auto pilot, high speed tilting train, automatic car park system, coin counter, engine management system, autonomous mobile system, antilock brake system control, Auto-Focus Camera, Printer, Domestic Washing Machine, Optical Mark Reader, Bar Code Reader and Pick and Place robot Arm, Using PLC for extending and retracting a pneumatic piston and two pneumatic pistons in different combinations, control of vibrating machine, control of process tank, control of conveyor motor, detecting, sorting and packaging unit.

## **ROBOTICS**

Fundamentals of Robot Technology: Robot definition, automation and robotics, Robot anatomy, Work volume, Drive systems. Control systems and dynamic performance. Accuracy and repeatability. Sensors and actuators used in robotics. Machine Vision, Robot configurations, Path control.

Introduction to robot languages. Applications; Types (Mobile, Parallel); Serial: Cartesian, Cylindrical, etc.; Social Issues. Robot Kinematics :Mapping, Homogeneous transformations, Rotation matrix, Forward Kinematics(DH Notation) and inverse kinematics: Closed form solution. Robot Differential Motion: Linear and Angular velocity of rigid link, Velocity along link, Manipulator jacobian, Statics: Use of jacobian. Robot Dynamics: Lagrangian Mechanics, Lagrangian Formulation and numericals. Dynamics, Newton-Euler Recursive Algorithm, Simulation. Euler-Lagrange Equations of motion/Any one other formulation like using Decoupled Natural Orthogonal Complements (DeNOC). End effectors: Mechanical and other types of grippers. Tools as end effectors. Robot and effector interface. Gripper selection and design. Applications for Manufacturing. Flexible automation. Robot cell layouts. Machine interference. Other considerations in work cell design. Work cell control, interlocks. Robot cycle time analysis. Mechanical design of robot links. Typical applications of robots in material transfer, machine loading/unloading; processing operations; assembly and inspection.

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