

## MECHATRONICS OPTION IN B.SC. MECHANICAL ENGINEERING

NOTE: Following is the detail of courses studied by Mechatronics students only. The remaining courses are common with Mechanical Engineering students.

### **MTN-206 Thermodynamics**

*Basics of Thermodynamics:* The system, working substance, heat and work, state and properties, temperature scales, processes and cycles. PV diagram, Internal energy, specific heats. Ideal gas laws, equations of state, first law of thermodynamics, system and control volume concept. Application of conservation of energy principle to isobaric, isochoric, isothermal, adiabatic, isentropic and polytropic processes. Second law of thermodynamics and its consequences, reversibility. Heat engines, thermal efficiency of reversible and irreversible engines, the Carnot cycle. Concept of entropy and its application to flow and non-flow processes. Available and unavailable energy, isentropic process, enthalpy-entropy diagram.

*Physical Properties of Steam:* The formation of steam, the triple point, quality of steam, sub-cooled liquid, enthalpy of steam, steam tables, PV diagram for steam, the critical point, behaviour of vapor in different thermodynamics processes.

*Fuels and Combustion:* Solid, liquid and gaseous fuels. Combustion equations. Stoichiometry. Enthalpy of formation. First law analysis for reacting substances. Internal energy and enthalpy of combustion. Combustion efficiency.

#### **Recommended Books:**

1. Fundamentals of Classical Thermodynamics, by Van Wylen and Soutagg, John Wiley.
2. Fundamentals of Thermodynamics by Moran and Shapiro.

### **MTN-303 Dynamic Systems Modeling**

*Introduction:* Mathematical modeling, simulation, analysis and design. Review of Laplace Transforms.

*Mechanical Systems:* Springs, dampers, and inertia elements. Translational and rotational systems. Energy methods. Transfer functions. Block diagrams. State space approach to system modeling.

*Electrical Systems:* Review of electrical elements and circuit analysis. Transfer functions of electrical circuits. Complex impedances. Analogous systems. Modeling of DC servomotors. Modeling of operational amplifier systems.

*Fluid and Thermal Systems:* Liquid level systems. Pneumatic systems. Linearization. Hydraulic systems. Thermal systems.

*Time Domain Analysis:* Step and ramp response of first order systems. Free response and step response of second order systems. Solution of the state equation.

*Frequency Domain Analysis:* Frequency response function.

*Performance Specifications:* Rise time, delay time, peak time, settling time, percentage overshoot, steady state error, stability, gain and phase margins.

**Recommended Books:**

1. System Dynamics, by K Ogata, Pearson Education.

### **MTN-306 Signal Measurement and Conditioning**

General Measurement System, Static and Dynamic Measurement, Calibration, Accuracy, Precision, Range, Sensitivity, repeatability, sensor's fusion.

Operational Modes of Instrumentation: Null instruments, Deflection Instruments, Analog and digital read out instruments. Input impedance, Static and dynamic characteristics of Instruments

Measurement Standards: Standard and its types, Numbers dimensions and units, Multiplication factors

Analog Filters, Modulators and Demodulators, Pulse Modulation, Analog-Digital Conversion, Sample and Hold Circuitry, Analog and Digital Multiplexers, Digital Filters, Bridge circuits, Digital Signal, Signal Analyzers, Oscilloscopes, Digital Signal Processing, Components Interconnection and Impedance Matching

Measurement of Pressure, Flow and Temperature, Digital Transducers -- Types and Applications.

**Recommended Books:**

1. Measurement Systems: Application & Design, by Doebelin, Tata McGraw Hill.
2. Signal and System by Oppenheim and Willsky, Prentice Hall
3. Signal and Linear System Analysis by G.E Carlson, Wiley.
4. Digital Signal Processing by Xavier, S.Chand

### **MTN-307 Electronic Circuits**

*Circuit Diagrams:* Commonly Used Symbols, Types of Diagrams and Their Uses and Applications, Schematic Diagrams, Wiring, Printed-Circuit diagrams, Block and Pictorial Diagrams.

*Components:* Basic Principles of Electrical Switching, Different types of Switches, Solenoids, Relays, Operational Amplifiers – Types and Analysis, Timers and Counters.

*Electronic Circuits Analysis:* Use of Diodes and Transistors in Circuits, Integrated Circuits, SCR, UJT, Diac and the Triac, Thyristors, Light-Activated Semiconductors and Optoisolators

*Introduction to Power Supplies*

*Introduction to Mechatronics: Need, History, Applications, Basic System Elements: Sensors, Actuators, Signal Conditioners, Microprocessors and Microcontrollers, Interfacing.*

**Recommended Books:**

1. Industrial Control Electronics By John Merrill
2. Principles of Industrial Instrumentation, by Patranabis, McGraw Hill.
3. Industrial Electronics & Control by Bhattacharya, McGraw Hill.

**MTN-402 Sensors and Actuators**

*Electrical Actuators:* Review of Electrical Motors and their types, Motor Equations, Drivers, and Control of DC Motors, Induction Motors, Synchronous Motors, and Stepper Motors.

*Hydraulic Actuators:* Pumps and its Different Types, Hydraulic Motors and Its Different Types, Valves and Its Different Types, Power Supplies, Cylinders, Accumulators, Intensifiers, Lifts, Couplings, Torque Converters. Hydraulic Circuit Design and Analysis.

*Pneumatic Actuators:* Compressors, Fluid Conditioners, Pneumatic Cylinders, Valves and Plugs, Basic Pneumatic Circuit Design & Analysis, Accumulator system Analysis

*Motion Transducers:* Potentiometer, Variable Inductance Transducers, Permanent Magnet Transducers, Variable Capacitance Transducers, Piezoelectric Transducers, and Proximity Transducers

*Effort Sensors:* Strain Gages, Torque Sensors, Tactile Sensors

**Recommended Books:**

1. Electric Motors and Control Techniques by Gottlieb, Irving *M.*, McGraw Hill
2. Fluid Power With Applications, by Anthony Esposito, Prentice Hall
3. Pneumatic Systems: Principles and Maintenance, by Majumdar, McGraw Hill
4. Electronic Instrumentation, by Kalsi, McGraw Hill
5. Digital Instrumentation, by Bouwens, McGraw Hill
6. Instrumentation for Engineering Measurements, by J W Dally, Wiley Eastern

**MTN-403 Microcontroller Programming and Interfacing**

*Introduction to Microcontrollers:* Motorola, PIC, and Intel Microcontrollers.

*MCS-51 Microcontrollers:* Overview, Pinouts, I/O Port Structure, Registers, Memory Organization, External Memory, Timer Operation, Ports Operation, Interrupts, Assembly Language programming,

*Interfacing Exercises:* Single Board Computer, Hexadecimal Keypad, 7-Segment LED, ADC, Stepper Motor etc

**Recommended Books:**

1. The 8051 Microcontroller by I.Scott Mackenzie, Prentice Hall.
2. Programming & Customizing the 8051 Microcontroller by Predko, McGraw Hill.

### **MTN-407 Control Systems**

*Basic Concepts:* System, Control System, Open Loop and Closed-Loop Control Systems. Elements of a General Control System, Examples of Control System, Transfer function of closed-loop control system.

Block Diagram Algebra and Signal Flow Graphs.

*Stability:* Definitions. Routh Stability Criterion,

*Root-Locus Method:* Root locus analysis and design. Lag-Lead Compensation, Parallel Compensation.

*PID Controllers:* Introduction. Tuning rules, Zero-placement approach to improve response

*Analysis and design of control systems in state space:* State space representation of transfer function, Controllability, Observability, Pole placement using state feedback, Ackermann's formula, internal model design

*Introduction to Discrete-Time Control Systems:* Digital control systems, Quantizing and quantization error, Data acquisition and distribution

*The Z Transform:* Z Transform, Z transform of elementary functions its properties and theorem, Inverse z transform

*Z-plane Analysis of Discrete –Time Control Systems:* Impulse sampling and data hold, obtaining the z transform by the convolution integral method, Reconstructing original signal from sampled signals, Pulse transfer function, Digital controllers, Mapping between s plane and z plane, Stability analysis of closed loop system in z plane, Transient and steady state response analysis

#### **Recommended Books:**

1. Modern Control System by Richard C Dorf and Robert H.
2. Modern Control Engineering by Katsuhiko Ogata
3. Discrete-Time control System by Katsuhiko Ogata, Pearson Education.
4. Digital Controls of Dynamic Systems by Gene F Franklin, J David Powell, and Michael Workman, Pearson Education

### **MTN-408 Robotics**

Automation and Robotics. Robot Classification. Robot Specifications.

*Direct Kinematics:* Mathematical background. D-H representation. The Arm equation. Examples

*Inverse Kinematics:* The inverse kinematics problem and its solution. Tool configuration. Examples of various robots.

*Introduction to Manipulator Dynamics:* Lagrange's Equation, Lagrange-Euler Dynamic Model.

Use of Sensors and Vision System in Robotic System.

**Recommended Books:**

1. Fundamentals of Robotics, by Robert J. Schilling, Prentice Hall
2. Robotics And Control by R K Mittal & I J Nagrath, McGraw-Hill
3. Introduction to Robotics Mechanics and Control by Craig, Pearson

**MTN-409 Industrial Automation**

*Introduction to automation:* Economics of Automation, Flow Lines, Mathematical Models, Storage Buffers, Partial Automation, Balancing, Group Technology and Flexible Manufacturing.

*Programmable Logic Controllers*

Introduction to PLCs, Advantages of PLCs, Ladder Logic Diagrams, Switching Logic.

Components of PLC, PLC Operating Cycle, Additional Capabilities of a PLC, Latches, Design Cases (Deadman Switches, Conveyor, Accept/Reject Sorting), Addressing.

PLC connection, PLC operation, Numbering, Event based logic, sequential logic design, Advanced ladder logic functions.

PLC Programming, Structured text programming, Instruction list programming, Function block programming, Continuous control, PLC data communication, Human Machine Interfaces (HMI), Selecting a PLC.

*CNC Machines*

General information, Operation, Control panel descriptions, Tool function, Practical application of tool wear offset, feed function, spindle function, programming of CNC in absolute and incremental systems, program creation, preparatory functions,

CNC Programming, Computer assisted part programming, Automatically programmed tools (APT Programming System), CAD/CAM approach to part programming, CAD/CAM application (turning problem, surface milling, machining of curved surfaces.)

**Recommended Books**

1. Automation, Production System and Computer Integrated Manufacturing by Mikell P. Groover, Prentice Hall.
2. CAD/CAM From Principles to Practice by Chris McMahon and Jimmie Browne, Addison Wesley Publishing Company

**MTN-410 Mechatronics System Design**

*Computer Interfacing:* Interfacing, Input/Output Ports, Interfacing Requirements, Peripheral Interface Adapter, Centronics Parallel Interface, Serial Communication and USB Interface, Interface Programming.

Introduction to Image Processing.

Interfacing Using different Microcontrollers: Intel, PIC, and Motorola

Overview of a Mechatronics System, Design of Mechatronics Systems, Case Studies.

*Mini Project:* Design, Analysis and Implementation of a Mechatronics System using all the concepts learned so far.

**Recommended books:**

1. Mechatronics, Electronic Control Systems In Mechanical And Electrical Engineering 2<sup>nd</sup> Edition by W. Bolton, Pearson Education
2. Real Time Systems and Software by Shaw, Wiley Eastern
3. Parallel Port Complete Programming, Interfacing, & Using the PC's Parallel Printer Port by Jan Axelson ISBN 0-9650819-1-5.