AUTOMATION & ROBOTICS

PROFESSIONAL ELECTIVE

SEMESTER – FIFTH

These important questions have been prepared using your previous exam papers (PYQs), verified concepts, and additional reference from trusted online academic sources.
For deeper understanding, please refer to your class notes as well.

1️⃣ HIGH & LONG IMPORTANT QUESTIONS (90–95% expected)

📝 Unit 1 & 2: Introduction & Automation Systems

1. Define **Industrial Automation**. Explain the necessity and various **benefits** of implementing industrial automation in modern manufacturing, particularly in the automotive industry.
2. Draw and explain the **Automation Hierarchy** (or pyramid) used in industrial control systems. Briefly describe the function of each level.
3. Compare and contrast **Relay Logic Control** with **Programmable Logic Controller (PLC)** Logic Control systems, highlighting their advantages and disadvantages in industrial applications.
4. Discuss the **key development milestones in the history of automation technology** and analyze the **effects of automation on people** (e.g., employment, skill requirements).

📝 Unit 3: Programmable Logic Controller (PLC)

1. Draw the **Internal Architecture of a PLC** and explain the function of its major components, including the CPU, I/O Modules, and Memory organization.
2. Explain the different types of **PLC Programming** methods and detail the standard **IEC 1131-3 Symbols** used for I/O devices in a Ladder Diagram.
3. Explain the working principle and application of **Timer functions (On-Delay and Off-Delay)** and **Counter functions** in PLC programming for process control. Provide a suitable real-world example for each.

📝 Unit 4: Input/Output Devices & Sensors

1. Explain the construction, working principle, and applications of the following **Proximity Switches**: **Inductive**, **Capacitive**, and **Photoelectric Sensors**.
2. Describe the working principle and industrial application of different types of **Input Devices** used for measuring process variables:
    - **Strain Gauges**
    - **Pressure Sensors**
    - **Resistive Temperature Detectors (RTDs)**
3. Explain the principle of operation for **Analog-to-Digital Converters (ADC)** and **Digital-to-Analog Converters (DAC)**. Why are these crucial in modern automation systems?

📝 Unit 5: Actuators & Motors

1. Explain the construction, working, and applications of the following **AC/DC Motors** used as actuators in automation systems:
    - **Stepper Motor**
    - **Servo Motor**
2. Describe the working principle and industrial uses of **Relays** and **Directional Control Valves** as common output devices in control circuits.

📝 Unit 6: Embedded Systems & FMS

1. Draw the **Block Diagram of an Embedded System** and explain the role of each component. List and briefly explain at least four key **Applications of Embedded Systems** in the automotive sector (e.g., ABS, Engine Control).
2. Define **Flexible Manufacturing Systems (FMS)**. Explain the different **types of FMS** (e.g., Single-machine cell, Dedicated FMS) and detail the essential **Components of FMS** (Work stations, Material Handling, Control System).

📝 Unit 7: Material Handling Systems

1. Explain the concept and need for **Automated Guided Vehicles (AGVs)**. Describe the various **AGV Guided Technologies** (e.g., wire, laser) and briefly discuss **AGV Safety Systems**.
2. Describe the main **Components of an Automated Storage/Retrieval System (AS/RS)** and explain their function in modern logistics and manufacturing.

📝 Unit 8 & 9: Robotics Introduction

1. Define a **Robot** and explain the need for using **Robotics** in industrial manufacturing. List and explain the primary **Specifications of an Industrial Robot**.
2. Describe the **Basic Components of an Industrial Robot** (Base, Link, Joint, Wrist, End effector, Actuator, Sensor, Controller). Draw a neat diagram to illustrate the setup.
3. Explain the different **Configurations of Robots** (e.g., Articulated, Polar, SCARA, Cartesian) with the help of simple sketches. Define and explain the concept of **Work Volume**.

📝 Unit 10: Robot Mechanisms

1. Define **Degree of Freedom (DOF)** for a robot manipulator. Explain the six basic degrees of freedom (Forward/Back, Up/Down, Left/Right, Pitch, Yaw, Roll).
2. List and describe the different **Joint Notations and Types of Joints** (L, O, R, T, V) found in a robot arm.
3. Differentiate between the three main types of **Robotic Drives** used for robot actuation: **Electric, Pneumatic, and Hydraulic Drives**.

📝 Unit 11: End Effectors & Control

1. What are **End Effectors**? Differentiate between **Grippers** and **Tools** as end effectors. List and explain the **Factors to be considered for selecting a Gripper** for a given application.
2. Explain the working principle and typical applications of the following **Robot Control Systems**:
    - **Point-to-Point (PTP) Control**
    - **Continuous Path (CP) Control**
    - **Intelligent Control**

📝 Unit 12 & 13: Programming & Applications

1. Describe the various **Robot Programming Methods** (Teach Pendant, Programming by using Languages, Offline Programming and Simulations), explaining the advantages of **Offline Programming**.
2. Explain the application of robots in **Arc Welding**. Describe the essential **Arc Welding Application commands** and the importance of **Weld Parameters** in achieving quality welds.

2️⃣ IMPORTANT & SHORT QUESTIONS (50–70% probability)

1. Write a short note on the importance and scope of **Automation & Robotics in the Automobile Industry**.
2. List and briefly describe the **Basic Components of an Automation System**.
3. Write the ladder logic diagram for the **basic logic gates** (AND, OR, NOT, NAND, NOR).
4. Differentiate between **Mechanical Switches** and **Proximity Switches**.
5. Explain the function of **Encoders** and **Liquid Level Detectors** in industrial sensing.
6. Distinguish between **DC Motors** and **Synchronous Motors** based on their characteristics in automation.
7. What are the key parameters to consider for the **selection of a PLC** for a given application?
8. Briefly explain the **four main types of FMS Layout Configurations** (Inline, Loop, Open Field, Robot Centered Cell).
9. Explain the terms **Robot Manipulator** and **Mobile Robot** with examples.
10. Differentiate between a **Joint Co-ordinate System** and a **Rectangular Co-ordinate System** in robotics.
11. Define **End Effector** and explain the difference between a **Gripper** and a **Tool**.
12. List and briefly explain the application of any four different types of **Sensors used in an Industrial Robot** (e.g., Tactile, Proximity, Optical).
13. Write a short note on the importance of **TCP (Tool Center Point Definition)** in robot programming.
14. Explain the difference between **Via Point** and **Process Point** in robot motion programming.
15. Briefly explain the **Low Air Pressure Interlock** system in a robotic cell with pneumatic grippers.

3️⃣ "AA BHI SAKTA HAI" QUESTIONS (20–30% probability)

1. Briefly discuss the ethical and social concerns related to the massive deployment of robots in the industry.
2. Explain the role of **Communication Protocols** in interfacing different devices (like sensors, PLC, and HMI) in a large-scale automation system.

3. Describe the concept of **Smart Sensors** and why they are advantageous over traditional sensors.
4. What are the different types of **Memory Organization** within a PLC?
5. How is a **SCADA system** related to the higher levels of the Automation Hierarchy?
6. Discuss the role of **CAD/CAM** in the modern practice of Robotics and Automation.
7. Explain the process of **calibrating a work object** in robot programming.
8. Write a short note on the application of robots in **Spray Painting**.
9. Explain the concept of **Low Air Pressure Interlock** in a robotic cell.
10. Briefly explain the purpose of **HAND INSTRUCTIONS** and **HANDLING WINDOW** in robot programming dedicated to material handling.

QUICK REVISE

🤖 Chapter 1 & 2: Introduction to Automation & Robotics

Topic	Key Points
Industrial Automation (IA)	Use of control systems (like PLC, Computers) and other technologies for automatically controlling industrial processes.
Need & Benefits	Increases **productivity**, improves **quality/consistency**, reduces **operational costs**, improves **safety** (by removing humans from hazardous tasks).
Automation Hierarchy	The control structure: **Field Level** (Sensors/Actuators) ->**Control Level** (PLC/DCS) ->**Supervisory Level** (SCADA/HMI) ->**Information Level** (ERP/MES).

Types of Automation ## 1. Fixed/Hard (high volume, fixed sequence, e.g., assembly line). 2. Programmable (medium volume, easy sequence change, e.g., CNC machine). 3. Flexible (low/medium volume, fast sequence change, e.g., FMS).

Basic Components ## Power Source, Control System (PLC/Controller), Program, Sensors (Input), Actuators (Output/Execution).

Relay Logic vs. PLC ## Relay Logic: Wired logic, hard to modify, large, high power consumption. PLC: Programmed logic, easy to modify, compact, reliable, faster.

💡 Chapter 3 & 4: PLC and Input Devices (Sensors)

Programmable Logic Controller (PLC)

Topic	Key Points
PLC Architecture	**CPU** (Microprocessor + Memory), **I/O Modules** (Input and Output Interfaces), **Programming Device** (PC/Teach Pendant), **Power Supply**.
I/O Modules	**Input Module:** Converts field signals (sensors) to digital signals for CPU. **Output Module:** Converts CPU signals to field signals (actuators).
Memory Organization	**System ROM** (OS, fixed), **User RAM** (stores ladder program and data), **I/O Image Table** (status of all I/O points).
Programming Standards	**IEC 1131-3** defines standard languages: **Ladder Diagram (LD)**, **Structured Text (ST)**, **Function Block Diagram (FBD)**, **Instruction List (IL)**.

PLC Programming: Functions

Function	Diagram/Concept	Application
Ladder Diagram	Uses symbols resembling relay contacts and coils to represent logic. Read left-to-right (Rungs).	Implementing logical control (AND, OR, NOT gates, Latching).
Timers	**TON** (On-Delay): Output goes ON *after* the input has been ON for a set time. **TOF** (Off-Delay): Output goes OFF *after* the input has been OFF for a set time.	Sequential operation, delaying motor start, controlling cycle time.
Counters	**CTU** (Up-Counter): Counts events (input pulses) up to a preset value. **CTD** (Down-Counter): Counts down from a preset value.	Counting items on a conveyor belt, batch processing.

Input Devices (Sensors)

Device	Working Principle	Application
Inductive Proximity	Detects **metallic** objects by change in magnetic field/inductance.	Object sensing, limit switching in harsh environments.
Capacitive Proximity	Detects **any material** (metal, plastic, liquid) by change in capacitance.	Level sensing for liquids/solids, non-metallic object detection.
Photoelectric	Uses light beam (LED/Laser) and receiver to detect presence. **Types:** Through-beam, Diffuse, Retro-reflective.	Counting products, large object detection, door automation.
Encoders	Convert angular/linear motion into digital codes (pulses). **Types:** Absolute, Incremental.	Measuring motor speed, position, and distance.
Strain Gauges	Converts small mechanical strain (force/weight) into a change in electrical resistance.	Weighing systems (Load Cells), stress analysis.
RTD/Thermocouple	**RTD:** Resistance changes linearly with temperature. **Thermocouple:** Generates voltage proportional to temperature difference (Seebeck Effect).	Industrial process temperature measurement.

Device	Working Principle	Application
ADC/DAC	**ADC:** Converts Analog signal (voltage/current from sensor) to Digital signal (for CPU). **DAC:** Converts Digital signal (from CPU) to Analog signal (for actuators).	Interfacing continuous process variables with digital controllers.

Chapter 5: Output Devices (Actuators)

Device	Working Principle	Application
Relay	Electromagnetic switch; uses a small electrical current to switch a larger current ON/OFF.	Isolation, switching high power loads.
Directional Control Valve (DCV)	Directs or controls the flow of pressurized fluid (air/oil) to an actuator (e.g., cylinder).	Controlling pneumatic/hydraulic cylinders and motors.
Stepper Motor	Rotates in discrete angular steps. Requires a driver/controller to send pulse sequence. **Used for: Precise position control** (Open loop).	Positioning, indexing tables, 3D printers.

Device	Working Principle	Application
Servo Motor	Works with a closed-loop feedback system (encoder/resolver) for accurate position, velocity, and torque control.	**High-precision, high-dynamic applications**, robotics.
DC/Synchronous Motor	**DC Motor:** Used when variable speed/torque control is needed. **Synchronous Motor:** Runs exactly at synchronous speed (tied to supply frequency).	General rotary motion, conveyors, pumps.

🏭 Chapter 6 & 7: Embedded Systems & FMS

Embedded Systems

Topic	Key Points
Embedded System	A specialized computer system designed to perform one or a few dedicated functions, often in real-time.
Block Diagram	**Microcontroller/Processor** (Core) ->**Memory** (Program/Data) ->**Input Ports** (Sensors) ->**Output Ports** (Actuators) ->**Bus/Power Supply**.
Applications (Automotive)	Engine Control Unit (**ECU**), Anti-lock Braking System (**ABS**), Keyless Entry, Airbag deployment systems.

Flexible Manufacturing System (FMS)

Topic	Key Points
FMS	A manufacturing system designed to be flexible in adapting to changes in the type and quantity of products being produced.
Components	1. **Workstations** (CNC, machines). 2. **Material Handling System** (AGVs, conveyors). 3. **Computer Control System** (Centralized control). 4. **Storage Systems** (AS/RS).
Types of FMS	**Dedicated FMS** (few products, high volume) and **Random Order FMS** (many products, low volume).
FMS Layouts	**Inline, Loop, Open Field, Robot-Centered Cell**. (Layout choice depends on material flow complexity).
AGVs	**Automated Guided Vehicles** (driverless vehicles for material transport). **Guidance:** Wire, Optical tape, Laser (most flexible).
AS/RS	**Automated Storage/Retrieval Systems**. Components: **Storage Structure** (Racks), **S/R Machine** (Crane), **Storage Modules** (Pallets), **P&D Stations**.

🦾 Chapter 8 & 9: Industrial Robotics

Topic	Key Points
Industrial Robot	An automatically controlled, reprogrammable, multi-purpose manipulator programmable in three or more axes.
Basic Components	**Manipulator** (Body, Arm, Wrist) + **End-Effector** (Gripper/Tool) + **Controller** + **Power Supply** + **Sensors**.

Robot Specifications :- Degrees of Freedom (DOF) (axes of motion), Work Volume (reach/workspace), Payload (max load), Repeatability (accuracy).

Degree of Freedom (DOF) :- The number of independent axes of motion (e.g., 6 DOF for industrial robots: 3 translational, 3 rotational).

Work Volume :- The total space the robot's end effector can reach. Varies by configuration.

Robot Configurations

Configuration	Description	Joint Type (Typical)	Work Volume Shape
Articulated (Revolute)	Resembles a human arm with rotating joints (Shoulder/Elbow/Wrist).	**R-R-R** (Revolute)	Spherical
SCARA	Selective Compliance Assembly Robot Arm. Two parallel revolute joints for high speed, vertical assembly.	**R-R-P** (Rotational-Rotational-Prismatic)	Cylindrical (Flat)
Cartesian	Three prismatic joints (L-O-L). Moves in X, Y, Z coordinates.	**L-O-L** (Linear-Orthogonal-Linear)	Rectangular/Cubic
Polar	Combination of rotational and linear movements to reach points in a spherical envelope.	**R-T-L** (Rotational-Twisting-Linear)	Spherical

Robot Joints

Joint Type	Motion	Notation
Linear	Translational along an axis	L
Orthogonal	Translational to the adjacent axis	O
Rotational	Rotational about a parallel axis	R
Twisting	Rotational about the link axis	T
Revolving	Rotational about an axis perpendicular to the previous axis	V

⚙️ Chapter 10 & 11: End Effectors and Control

End Effectors

Topic	Key Points
End Effector	The device connected to the robot's wrist that interacts with the environment.
Grippers	**Hold and grasp** objects. Types: Mechanical (Jaws), Vacuum, Magnetic, Adhesive. **Selection Factors:** Weight, shape, material, cycle time.
Tools	**Perform a process** (not grasping). Examples: Weld torch, Paint spray gun, Drill, Milling head.

Robot Control Systems

Control System	Description	Application
Point-to-Point (PTP)	Robot is taught and moves only to specific end points (start/stop) with no control over the path between points.	Pick and place, simple material handling.
Continuous Path (CP)	Robot is taught an entire trajectory/path, and the controller ensures the end	Arc welding, spray painting,

Control System	Description	Application
	effector follows the programmed path precisely.	contour following.
Intelligent Control	Uses external sensors (vision, force) and complex algorithms to adjust path/motion dynamically in real-time.	Bin picking, assembly of non-uniform parts.

Robot Coordinate Systems

System	Description
Joint	Defines position by the angle/extension of each joint relative to the home position.
Rectangular (World)	Fixed global X, Y, Z axes, independent of the robot's structure.
Tool	Coordinate system attached to the End Effector (Tool Center Point - TCP). Moves with the tool.
User/Object	Fixed to a fixture or work area. Useful for programming moves relative to a specific part.

💻 Chapter 12: Robot Programming

Topic	Key Points
Teach Pendant	A handheld device used for manually moving the robot and recording position points. **Method: Teaching/Lead-through** programming.
Programming Languages	High-level languages (e.g., KUKA KRL, ABB RAPID) used for complex logic, calculations, and external communication.
Offline Programming	Creating the robot program on a **PC using simulation software** without using the actual

Topic	Key Points
	robot. **Benefits:** Robot uptime is maximized, error checking before deployment.
Motion Types	**PTP (Point-to-Point):** Fastest path, not linear. **Linear:** Straight-line movement between points (constant speed). **Circular:** Interpolated arc movement.
TCP	**Tool Center Point**. The critical point on the end effector (e.g., tip of a weld wire). **Definition/Calibration** ensures all moves are relative to this point.

Key Application Commands

Application	Core Command/Concept	Purpose
Material Handling (Pick & Place)	MoveJ (Joint), MoveL (Linear), Gripper I/O (HAND INSTRUCTIONS).	Moving parts between conveyors/fixtures.
Arc Welding	ARCON, ARCOFF, WEAVON, WEAVOFF. **Parameters:** Voltage, Amperage, Wire Feed Speed, Travel Speed.	Controlling the arc start/stop and weld trajectory.
Spray Painting	Uses Continuous Path (CP) control, often with velocity and flow rate control based on the path curvature.	Applying a uniform coating over a surface.