МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
Київський електромеханічний фаховий коледж

ІНОЗЕМНА МОВА ЗА ПРОФЕСІЙНИМ СПРЯМУВАННЯМ

ПРАКТИЧНІ ЗАВДАННЯ ДЛЯ РОЗВИТКУ ПРОФЕСІЙНОГО МОВЛЕННЯ

НАВЧАЛЬНИЙ ПОСІБНИК

для студентів спеціальності «Автоматизація, комп'ютерно-інтегровані технології та робототехніка»

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Для студентів спеціальності «Автоматизація, комп’ютерно-інтегровані технології та робототехніка» англійська мова є основною для успішного навчання та кар’єри. Вивчення термінології, граматики та особливостей мови, яку використовують фахівці галузі, дозволяє не лише розуміти технічну документацію, а й ефективно спілкуватися в професійному середовищі. Цей посібник є першою частиною трилогії, охоплює чотири розділи Fundamentals of Automation and Control, Programmable Logic Controllers (PLCs), Robotics and Mechatronics та Industrial Sensors and Measurement Systems і спрямований на поповнення у здобувачів освіти словникового запасу професійного спрямування та розвитку вміння оперувати відповідною лексикою під час усного та письмового спілкування. У цьому посібнику ми розглянемо основні терміни у галузі, що допоможуть здобувачам освіти стати компетентними в технічній англійській мові. Також посібник орієнтує здобувачів освіти на основні теми, які випливають з програмних результатів навчання, передбачених освітніми програмами в рамках спеціальності «Автоматизація, комп’ютерно-інтегровані технології та робототехніка».

РОЗГЛЯНУТО ТА СХВАЛЕНО

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Київського електромеханічного фахового коледжу
Протокол № від «___» _____ 2025 р.

Цикловою комісією філологічних дисциплін
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Науково-методичною радою
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ЗАТВЕРДЖЕНО
«_____» _____ 2025 р.
Заступник директора з навчальної роботи Олександр МАРЧЕНКО

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Посібник для розвитку професійного мовлення з навчальної дисципліни «Іноземна мова за професійним спрямуванням» для студентів спеціальності «Автоматизація, комп'ютерно-інтегровані технології та робототехніка»

Зміст

1. Основні терміни у галузі автоматизації та комп'ютерно-інтегрованих технологій (Key Terms in Automation and Computer-Integrated Technologies)

1. **Automation** – автоматизація
2. **Control system** – система керування
3. **Programmable logic controller (PLC)** – програмований логічний контролер (ПЛК)
4. **Supervisory control and data acquisition (SCADA)** – диспетчерське управління та збір даних
5. **Human-machine interface (HMI)** – інтерфейс людина-машина
6. **Distributed control system (DCS)** – розподілена система керування
7. **Real-time system** – система реального часу
8. **Embedded system** – вбудована система
9. **Feedback loop** – контур зворотного зв’язку
10. **Process control** – керування процесами

Робототехніка (Robotics)

11. **Robot arm** – роботизована рука
12. **End effector** – виконавчий механізм (ефектор)
13. **Actuator** – виконавчий пристрій
14. **Servo motor** – сервомотор
15. **Stepper motor** – кроковий двигун
16. **Manipulator** – маніпулятор
17. **Kinematics** – кінематика
18. **Degrees of freedom (DOF)** – ступені свободи
19. **Trajectory planning** – планування траєкторії
20. **Industrial robot** – промисловий робот

Датчики та сенсори (Sensors and Transducers)

21. **Sensor** – датчик
22. **Transducer** – перетворювач
23. **Proximity sensor** – датчик наближення
24. **Optical sensor** – оптичний датчик
25. **Pressure sensor** – датчик тиску
26. **Temperature sensor** – датчик температури
27. **Accelerometer** – акселерометр
28. **Gyroscope** – гіроскоп
29. **Infrared sensor** – інфрачервоний датчик
30. **Ultrasonic sensor** – ультразвуковий датчик

Програмування та алгоритми (Programming and Algorithms)

31. **Algorithm** – алгоритм
32. **Artificial intelligence (AI)** – штучний інтелект
33. **Machine learning (ML)** – машинне навчання
34. **Neural network** – нейронна мережа
35. **Fuzzy logic** – нечітка логіка
36. **Real-time operating system (RTOS)** – операційна система реального часу
37. **Python** – мова програмування Python
38. **Ladder logic** – релейно-контактна логіка
39. **Structured text (ST)** – структурований текст

40. **Function block diagram (FBD)** – діаграма функціональних блоків

Комунікаційні технології (Communication Technologies)

41. **Fieldbus** – польова шина
42. **Modbus** – протокол Modbus
43. **Profibus** – протокол Profibus
44. **Ethernet** – Ethernet
45. **CAN bus** – шина CAN
46. **Wireless communication** – бездротовий зв’язок
47. **IoT (Internet of Things)** – Інтернет речей
48. **Edge computing** – периферійні обчислення
49. **Cloud computing** – хмарні обчислення
50. **M2M (Machine-to-Machine)** – взаємодія між машинами

Системи керування та електроніка (Control Systems and Electronics)

51. **PID controller** – ПІД-регулятор
52. **Relay** – реле
53. **Microcontroller (MCU)** – мікроконтролер
54. **Microprocessor** – мікропроцесор
55. **Digital signal processing (DSP)** – цифрова обробка сигналів
56. **Power supply** – блок живлення
57. **Analog-to-digital converter (ADC)** – аналого-цифровий перетворювач
58. **Digital-to-analog converter (DAC)** – цифро-аналоговий перетворювач
59. **Printed circuit board (PCB)** – друкована плата
60. **Embedded software** – вбудоване програмне забезпечення

Мехатроніка (Mechatronics)

61. **Mechatronics** – мехатроніка
62. **Automation engineering** – інженерія автоматизації
63. **Hydraulics** – гідравліка
64. **Pneumatics** – пневматика
65. **Solenoid valve** – соленоїдний клапан
66. **Linear actuator** – лінійний виконавчий механізм
67. **CNC (Computer Numerical Control)** – комп’ютерне числове керування
68. **Stepper drive** – кроковий привід
69. **Servo drive** – сервопривід
70. **Haptic feedback** – тактильний зворотний зв'язок

Технологічні процеси та виробництво (Technological Processes and Manufacturing)

71. **Smart factory** – розумний завод
72. **Industry 4.0** – Індустрія 4.0
73. **Flexible manufacturing system (FMS)** – гнучка виробнича система
74. **Computer-aided design (CAD)** – автоматизоване проєктування
75. **Computer-aided manufacturing (CAM)** – автоматизоване виробництво
76. **Cyber-physical system (CPS)** – кібер-фізична система
77. **Digital twin** – цифровий двійник
78. **Predictive maintenance** – прогнозне обслуговування
79. **Lean manufacturing** – ощадливе виробництво

80. **Six Sigma** – методологія Six Sigma

Безпека та стандартизація (Safety and Standardization)

81. **Safety system** – система безпеки
82. **Functional safety** – функціональна безпека
83. **Redundancy** – резервування
84. **Fail-safe** – безпечне відмовлення
85. **Risk assessment** – оцінка ризиків
86. **ISO 9001** – стандарт ISO 9001
87. **IEC 61131** – стандарт для програмування ПЛК
88. **CE marking** – маркування CE
89. **Occupational safety** – охорона праці
90. **Cybersecurity** – кібербезпека

Новітні технології та перспективи (Emerging Technologies and Future Trends)

91. **Autonomous systems** – автономні системи
92. **Collaborative robot (Cobot)** – колаборативний робот
93. **Machine vision** – машинний зір
94. **Augmented reality (AR)** – доповнена реальність
95. **Virtual reality (VR)** – віртуальна реальність
96. **3D printing** – 3D-друк
97. **Quantum computing** – квантові обчислення
98. **Blockchain** – блокчейн
99. **Smart sensor** – інтелектуальний датчик
100. **Digital transformation** – цифрова трансформація

2. Англійська мова професійного спрямування. Important Topics for Students of "Automation, Computer-Integrated Technologies and Robotics"

1. Fundamentals of Automation and Control

- Introduction to Automation
- Basic Control System Components
- Open-Loop and Closed-Loop Control
- Sensors and Actuators in Automation
- Industrial Control Strategies

2. Programmable Logic Controllers (PLCs)

- Basics of PLCs
- PLC Programming Languages (Ladder Logic, Structured Text, Function Block Diagram)
- PLC Communication Protocols
- Real-Time Monitoring and Troubleshooting
- SCADA and HMI Systems

3. Robotics and Mechatronics

- Introduction to Robotics
- Robot Kinematics and Dynamics
- Types of Industrial Robots

- End Effectors and Grippers
- Robot Motion Planning and Path Control

4. Industrial Sensors and Measurement Systems

- Types of Sensors (Proximity, Optical, Temperature, Pressure, etc.)
- Data Acquisition Systems (DAQ)
- Signal Conditioning and Filtering
- Sensor Fusion in Robotics
- Smart Sensors and IoT Integration

5. Embedded Systems and Microcontrollers

- Microcontrollers vs. Microprocessors
- Embedded System Design
- Real-Time Operating Systems (RTOS)
- Digital and Analog Signal Processing
- Interfacing Sensors and Actuators

6. Artificial Intelligence and Machine Learning in Automation

- Basics of AI and Machine Learning
- Neural Networks and Deep Learning in Robotics
- Machine Vision for Industrial Applications
- Predictive Maintenance using AI
- Fuzzy Logic and Expert Systems

7. Industrial Communication and Networking

- Communication Protocols (Modbus, Profibus, CAN, Ethernet/IP)
- Industrial Internet of Things (IIoT)
- Cloud Computing in Automation
- Edge Computing and Real-Time Data Processing
- Cybersecurity in Industrial Networks

8. Digital Twin and Industry 4.0

- Concept of Digital Twins
- Smart Manufacturing and Cyber-Physical Systems
- Advanced Automation with Industry 4.0
- Data Analytics in Manufacturing
- Augmented Reality (AR) and Virtual Reality (VR) in Industry

9. Motion Control and Drives

- Stepper and Servo Motors
- Motor Control Strategies (PID, Fuzzy Logic, AI-based)
- Variable Frequency Drives (VFDs)
- Motion Planning and Trajectory Optimization
- Haptic Feedback in Robotics

10. Pneumatics and Hydraulics in Automation

- Basics of Fluid Power Systems
- Hydraulic and Pneumatic Actuators
- Solenoid Valves and Flow Control
- Electro-Pneumatic Systems in Industrial Automation
- Energy Efficiency in Fluid Power Systems

11. Computer-Aided Design (CAD) and Manufacturing (CAM)

- Fundamentals of CAD Software
- 3D Modeling for Automation Systems
- CNC Machines and G-Code Programming
- Additive Manufacturing and 3D Printing
- Digital Prototyping and Simulation

12. Safety and Standards in Automation

- Functional Safety and Risk Assessment
- Safety PLCs and Emergency Stop Systems
- International Standards (ISO, IEC, ANSI, OSHA)
- Machine Safety and Human-Robot Interaction
- Fail-Safe and Redundancy Mechanisms

3. TOPICS

Fundamentals of Automation and Control

Topic 1. Introduction to Automation

Automation is the use of technology to perform tasks with minimal human intervention. It is widely applied in industries to improve efficiency, accuracy, and productivity. Automation systems can range from simple mechanical devices to complex computerized networks controlling entire production lines.

One of the key components of automation is the **control system**, which regulates processes based on predefined instructions. These systems can be **open-loop**, where the output is not monitored, or **closed-loop**, where sensors provide feedback for adjustments. **Programmable Logic Controllers (PLCs)** and **Supervisory Control and Data Acquisition (SCADA)** systems are commonly used to manage automated processes.

Automation has numerous advantages, such as increased production speed, reduced labor costs, improved safety, and higher quality control. However, it also presents challenges, including high initial costs, maintenance requirements, and the need for skilled professionals.

With advancements in **artificial intelligence (AI)** and **the Internet of Things (IoT)**, automation is evolving rapidly. Smart factories, **Industry 4.0**, and **cyber-physical systems** are transforming the way industries operate. As automation continues to develop, professionals in this field must stay updated with the latest technologies and innovations.

Tasks for Understanding and Vocabulary Practice

1. True or False

Decide whether the following statements are true or false. Correct the false statements.

1. Automation always requires human intervention.
2. Open-loop control systems use feedback from sensors.
3. PLCs are commonly used in automation systems.
4. Automation has no impact on labor costs.
5. Industry 4.0 is related to modern automation trends.

2. Multiple Choice

Choose the correct answer.

1. What is the main purpose of automation?
   a) To increase human involvement
   b) To reduce efficiency
   c) To improve productivity and accuracy
   d) To replace all machines
2. Which of the following is an example of a control system?
   a) Conveyor belt
   b) PLC
   c) Worker supervision
   d) Warehouse storage
3. What is one challenge of automation?
   a) Increased errors
   b) High initial costs
   c) Reduced quality control
   d) Less production speed

3. Fill in the Blanks

Complete the sentences using the words from the text: automation, control system, feedback, PLCs, safety.

1. A _____ regulates processes based on predefined instructions.
2. Sensors provide _____ in closed-loop systems.
3. Many factories use _____ to manage automated processes.
4. One of the benefits of _____ is improved accuracy.
5. Automated systems enhance worker _____ by reducing dangerous tasks.

4. Match the Terms with Their Definitions

Match each term with the correct definition.

1. **SCADA**
2. **IoT**
3. **Industry 4.0**
4. **Cyber-physical system**
5. **Artificial Intelligence**

a) A system that connects physical processes with digital technologies
b) The fourth industrial revolution focused on smart manufacturing
c) A technology that enables machines to learn and make decisions
d) A system used for monitoring and controlling industrial processes remotely
e) A network of connected devices that communicate and exchange data

5. Short Answer Question

In your own words, describe one benefit and one challenge of automation.

Topic 2. Basic Control System Components

A **control system** is a set of devices that manage, command, direct, or regulate the behavior of other devices or systems. Control systems are essential in automation, manufacturing, and industrial processes. They help maintain stability, efficiency, and accuracy in operations.

There are two main types of control systems: **open-loop** and **closed-loop**. In an **open-loop system**, the output is not measured or fed back to the input. Examples include simple timers and washing machines. In a **closed-loop system**, feedback is used to adjust the system's performance. A thermostat controlling room temperature is a common example.

The key components of a control system include:

- **Sensors** – Devices that measure physical parameters such as temperature, pressure, speed, and position. They provide data to the controller.
- **Controllers** – Devices like **Programmable Logic Controllers (PLCs)** or microcontrollers that process sensor data and send commands to actuators.
- **Actuators** – Components that perform actions, such as motors, solenoids, and hydraulic systems. They execute the controller’s instructions.
- **Feedback Mechanism** – A process that compares actual output with the desired output and makes necessary adjustments.
- **Human-Machine Interface (HMI)** – A user interface that allows operators to monitor and control the system.

Modern control systems are widely used in robotics, industrial automation, and smart technologies. They ensure precision and reliability in various applications, from factory machines to autonomous vehicles.

Tasks for Understanding and Vocabulary Practice

1. True or False

Decide whether the following statements are true or false. Correct the false statements.

1. A control system always requires human input to function.
2. Closed-loop systems use feedback to adjust performance.
3. Sensors are responsible for executing commands from the controller.
4. Actuators measure physical parameters such as temperature and pressure.
5. A thermostat is an example of an open-loop system.

2. Multiple Choice

Choose the correct answer.

1. What is the function of a controller in a control system?
   a) Measuring temperature
   b) Processing sensor data and sending commands
   c) Executing mechanical movements
   d) Monitoring system failures
2. Which of the following is NOT a component of a control system?
   a) Sensor
   b) Actuator
   c) Feedback mechanism
   d) Battery charger
3. Which device converts electrical signals into physical movement?
   a) Sensor
   b) Actuator
   c) HMI
   d) PLC

3. Fill in the Blanks

Complete the sentences using the words from the text: actuator, feedback, controller, sensors, HMI.

1. _____ collect data from the environment and send it to the controller.
2. The _____ sends signals to actuators to perform actions.
3. A motor is an example of an _____ that moves a mechanical system.
4. A _____ allows operators to monitor and control the system.
5. In a closed-loop system, _____ is used to correct errors and improve accuracy.

4. Match the Terms with Their Definitions

Match each term with the correct definition.

14. **Open-loop system**
15. **Closed-loop system**
16. **Sensor**
17. **Actuator**
18. **Controller**

a) A device that executes mechanical movements based on received commands
b) A system that operates without feedback from the output
c) A system that adjusts performance using feedback
d) A device that processes input signals and sends commands
e) A device that collects data from the environment

5. Short Answer Question

Explain why feedback is important in a control system. Provide an example.

Topic 3. Open-Loop and Closed-Loop Control

A **control system** is a system that manages and regulates the behavior of a machine or process. Control systems are widely used in automation, robotics, and industrial processes. There are two main types of control systems: **open-loop control** and **closed-loop control**.

Open-Loop Control

An **open-loop control system** operates without using feedback. This means that the system does not measure or adjust its output based on changes in the environment. Instead, it follows a predefined set of instructions. Open-loop systems are simple, cost-effective, and easy to design, but they are less accurate because they do not correct errors.

Examples of open-loop systems:

- A microwave oven that heats food for a set time, regardless of the actual temperature of the food.
- A washing machine that runs through a fixed cycle without checking if the clothes are clean.
- An irrigation system that waters plants on a timer, without measuring soil moisture.

Closed-Loop Control

A **closed-loop control system**, also called a **feedback control system**, continuously monitors its output and makes adjustments to achieve the desired result. This type of system uses **sensors** to measure the output and provides feedback to the **controller**, which then modifies the input to correct any deviations. Closed-loop systems are more complex and expensive but provide higher accuracy and efficiency.

Examples of closed-loop systems:

- A thermostat that adjusts the heating or cooling based on the room temperature.
- A cruise control system in a car that maintains a set speed by adjusting the engine power.
- A robotic arm that corrects its position based on real-time sensor data.

Key Differences Between Open-Loop and Closed-Loop Control

Feature	Open-Loop Control	Closed-Loop Control
Feedback	No feedback	Uses feedback
Accuracy	Less accurate	More accurate
Complexity	Simple design	More complex
Examples	Microwave, washing machine	Thermostat, cruise control

Both open-loop and closed-loop control systems play important roles in modern automation. While open-loop systems are useful for simple, repetitive tasks, closed-loop systems provide better control and precision, making them ideal for advanced industrial applications.

Tasks for Understanding and Vocabulary Practice

1. True or False

Decide whether the following statements are true or false. Correct the false statements.

1. Open-loop systems use feedback to adjust their performance.
2. A washing machine is an example of a closed-loop system.
3. Closed-loop control systems rely on sensors to measure output.
4. Open-loop systems are usually more accurate than closed-loop systems.
5. A thermostat is an example of a closed-loop control system.

2. Multiple Choice

Choose the correct answer.

1. What is the main difference between open-loop and closed-loop systems?
   a) Open-loop systems are more expensive.
   b) Closed-loop systems use feedback, while open-loop systems do not.
   c) Open-loop systems adjust performance based on sensors.
   d) Closed-loop systems do not require any external input.
2. Which of the following is an example of an open-loop system?
   a) A cruise control system in a car
   b) A microwave oven with a timer
   c) A robotic arm that adjusts its position based on feedback
   d) An air conditioning system with temperature sensors
3. What is the main disadvantage of an open-loop system?
   a) It is too complex to design.
   b) It cannot correct errors or adapt to changes.
   c) It is too expensive for industrial use.
   d) It requires too many sensors.

3. Fill in the Blanks

Complete the sentences using the words from the text: feedback, sensor, thermostat, controller, irrigation.

1. A _____ is a device that measures physical parameters such as temperature or pressure.
2. In a closed-loop system, _____ is used to adjust performance based on actual output.
3. A _____ is a common household example of a closed-loop system, adjusting temperature automatically.
4. A _____ is responsible for processing input and sending commands to the system.
5. An _____ system that waters plants on a timer is an example of open-loop control.

4. Match the Terms with Their Definitions

Match each term with the correct definition.

1. **Open-loop system**
2. **Closed-loop system**
3. **Sensor**

4. **Actuator**
5. **Controller**

a) A system that operates without feedback.
b) A device that collects data about the system's output.
c) A system that adjusts its performance using feedback.
d) A component that executes commands by moving or controlling a mechanism.
e) A unit that processes data and sends signals to control the system.

5. Short Answer Question

Explain why closed-loop systems are more accurate than open-loop systems. Provide an example.

Topic 4. Sensors and Actuators in Automation

Introduction
In automation, **sensors** and **actuators** are essential components that allow systems to interact with their environment. Sensors collect data from the physical world, while actuators perform actions based on control signals. These two components work together to enable automated systems in industries such as manufacturing, robotics, and smart technologies.

Sensors

A **sensor** is a device that detects physical or environmental conditions and converts them into electrical signals. Sensors provide data that is used by control systems to make decisions. There are many types of sensors, including:

- **Temperature sensors** – Measure heat levels (e.g., in HVAC systems).
- **Pressure sensors** – Detect pressure in liquids and gases (e.g., in hydraulic systems).
- **Proximity sensors** – Detect the presence of objects without contact (e.g., in automated doors).
- **Light sensors** – Measure the intensity of light (e.g., in automatic lighting systems).
- **Motion sensors** – Detect movement (e.g., in security systems).

Actuators

An **actuator** is a device that converts electrical signals into mechanical movement. Actuators execute the commands given by a control system. There are different types of actuators, including:

- **Electric actuators** – Use electric motors to create motion (e.g., robotic arms).
- **Hydraulic actuators** – Use pressurized fluid for movement (e.g., in heavy machinery).
- **Pneumatic actuators** – Use compressed air to generate force (e.g., in factory automation).
- **Thermal actuators** – Expand and contract based on temperature changes (e.g., in thermostats).

How Sensors and Actuators Work Together

In an automated system, sensors collect data and send it to a **controller** (such as a PLC). The controller processes the information and sends signals to the actuators to perform the necessary

actions. For example, in a smart irrigation system, a **moisture sensor** detects dry soil, the controller processes the data, and an actuator opens a valve to release water.

Sensors and actuators are fundamental to **Industry 4.0**, where smart technologies improve efficiency, precision, and automation in various industries. Understanding how they function is essential for engineers and technicians working with modern automated systems.

Tasks for Understanding and Vocabulary Practice

1. True or False

Decide whether the following statements are true or false. Correct the false statements.

1. Sensors and actuators perform the same function in automation.
2. A temperature sensor measures pressure in hydraulic systems.
3. Motion sensors are often used in security systems.
4. Actuators convert mechanical movement into electrical signals.
5. In a smart irrigation system, sensors detect soil moisture levels.

2. Multiple Choice

Choose the correct answer.

1. What is the main function of a sensor?
   a) To perform mechanical actions
   b) To collect and convert environmental data into electrical signals
   c) To generate compressed air for pneumatic systems
   d) To control hydraulic pressure
2. Which of the following is NOT a type of actuator?
   a) Electric actuator
   b) Pneumatic actuator
   c) Light sensor
   d) Hydraulic actuator
3. What type of sensor is commonly used in automatic lighting systems?
   a) Temperature sensor
   b) Proximity sensor
   c) Light sensor
   d) Motion sensor

3. Fill in the Blanks

Complete the sentences using the words from the text: actuator, proximity, controller, hydraulic, motion.

1. A _____ sensor can detect objects without physical contact.
2. An electric _____ converts electrical signals into mechanical movement.
3. A _____ system uses pressurized liquid to generate force.
4. The _____ processes data from sensors and sends commands to actuators.
5. A _____ sensor is commonly used in security alarms to detect movement.

4. Match the Terms with Their Definitions

Match each term with the correct definition.

1. **Sensor**
2. **Actuator**
3. **Controller**
4. **Hydraulic actuator**
5. **Motion sensor**

a) A device that detects movement and sends signals
b) A component that collects environmental data and converts it into an electrical signal
c) A system that processes input from sensors and sends commands to actuators
d) A device that uses pressurized fluid to create mechanical motion
e) A component that converts electrical signals into mechanical movement

5. Short Answer Question

Explain the relationship between sensors, controllers, and actuators in an automated system. Provide an example.

Topic 5. Industrial Control Strategies

Introduction
Industrial control strategies are methods used to regulate and optimize industrial processes, ensuring efficiency, safety, and reliability. These strategies help maintain system stability, improve productivity, and reduce operational costs. They are widely used in manufacturing, robotics, power plants, and automated systems.

Types of Industrial Control Strategies

1. Open-Loop Control

In an **open-loop control system**, the system operates without feedback. It follows predefined instructions without adjusting to changes in the environment. While simple and cost-effective, open-loop control lacks precision.

Example: A conveyor belt that runs at a fixed speed without adjusting for load variations.

2. Closed-Loop Control

A **closed-loop control system** (or **feedback control system**) continuously monitors output and makes adjustments based on feedback. This strategy improves accuracy and stability.

Example: A temperature control system that adjusts heating based on sensor readings.

3. PID Control (Proportional-Integral-Derivative Control)

PID control is one of the most widely used control strategies in industrial automation. It uses three components:

- **Proportional (P):** Adjusts the output based on the current error.
- **Integral (I):** Eliminates past errors by summing them over time.
- **Derivative (D):** Predicts future errors and adjusts the system accordingly.

Example: A robotic arm positioning system that requires precise motion control.

4. On-Off Control

On-off control is a simple control strategy where the system switches between two states: **ON** and **OFF**. It is commonly used when precise control is not required.

Example: A thermostat that turns a heater on when the temperature drops below a set value and turns it off when the temperature rises.

5. Feedforward Control

Feedforward control anticipates disturbances and adjusts the system before errors occur. Unlike feedback control, it does not rely on output measurement but rather on external factors.

Example: A chemical dosing system that adjusts the amount of reagent added based on flow rate measurements.

6. Adaptive Control

Adaptive control modifies system parameters in real time to accommodate changing conditions. This is useful in complex processes with variable inputs.

Example: An industrial robot that adjusts its grip strength based on object weight.

7. Model Predictive Control (MPC)

MPC uses mathematical models to predict future system behavior and optimize control actions. It is used in high-performance applications requiring precise control.

Example: Advanced process control in oil refineries.

Conclusion

Industrial control strategies are crucial for automation and efficient system operation. Choosing the right strategy depends on the complexity, accuracy, and stability required in a given process. As technology advances, intelligent and AI-driven control strategies are becoming increasingly popular in modern industries.

Tasks for Understanding and Vocabulary Practice

1. True or False

Decide whether the following statements are true or false. Correct the false statements.

1. Open-loop control systems adjust their output based on feedback.
2. PID control consists of proportional, integral, and differential components.
3. On-off control systems continuously adjust output for precision.
4. Feedforward control anticipates disturbances before they affect the system.
5. Adaptive control modifies system parameters in real time.

2. Multiple Choice

Choose the correct answer.

1. Which control strategy does NOT use feedback?
   a) Closed-loop control
   b) PID control
   c) Open-loop control
   d) Adaptive control
2. What is the main advantage of closed-loop control?
   a) Simplicity and low cost
   b) High accuracy and stability
   c) No need for sensors
   d) No energy consumption
3. Which of the following control strategies is best for high-precision applications?
   a) On-off control
   b) Model predictive control
   c) Open-loop control
   d) Feedforward control

3. Fill in the Blanks

Complete the sentences using the words from the text: PID, feedback, open-loop, feedforward, adaptive.

1. _____ control does not use feedback and follows predefined instructions.
2. _____ control adjusts system parameters in real time to accommodate changing conditions.
3. In a _____ system, the output is continuously monitored and adjusted based on input data.
4. _____ control uses mathematical models to predict future system behavior.
5. The _____ controller consists of proportional, integral, and derivative components.

4. Match the Terms with Their Definitions

Match each term with the correct definition.

1. **Open-loop control**
2. **Closed-loop control**
3. **PID control**
4. **On-off control**
5. **Feedforward control**

a) A control system that continuously adjusts output based on feedback.
b) A system that anticipates disturbances and makes adjustments before errors occur.
c) A simple control system with only ON and OFF states.
d) A control method with proportional, integral, and derivative components.
e) A system that operates without feedback.

5. Short Answer Question

Explain the difference between closed-loop and open-loop control systems. Provide one example for each.

Programmable Logic Controllers (PLCs)

Topic 6. Basics of Programmable Logic Controllers (PLCs)

Programmable Logic Controllers (PLCs) are digital computers used for the automation of electromechanical processes. Unlike general-purpose computers, PLCs are designed for multiple inputs and output arrangements, extended temperature ranges, immunity to electrical noise, and resistance to impact and vibration. They are widely used in industries to control and monitor machinery and processes.

Key Components of a PLC:

- **Central Processing Unit (CPU):** The brain of the PLC, it executes the program and makes decisions.
- **Input/Output (I/O) Modules:** These modules connect the PLC to sensors and actuators.
- **Power Supply:** Provides the necessary voltage to operate the PLC.
- **Programming Device:** Used to enter, edit, and monitor the PLC program.

How PLCs Work:

1. **Input Scan:** The PLC reads the status of all input devices.
2. **Program Scan:** The CPU executes the user-defined program.
3. **Output Scan:** The PLC updates the status of all output devices.

Programming Languages:

PLCs can be programmed using various languages, including:

- **Ladder Logic (LD):** A graphical language that resembles electrical relay diagrams.
- **Function Block Diagram (FBD):** A graphical language that uses blocks to represent functions.
- **Structured Text (ST):** A high-level text-based language.

Applications of PLCs:

PLCs are used in a wide range of applications, including:

- Manufacturing: Controlling assembly lines, robotic systems, and packaging machines.
- Automotive: Controlling engine assembly, painting, and welding processes.
- Energy: Monitoring and controlling power generation and distribution.

Tasks for Understanding and Vocabulary Practice

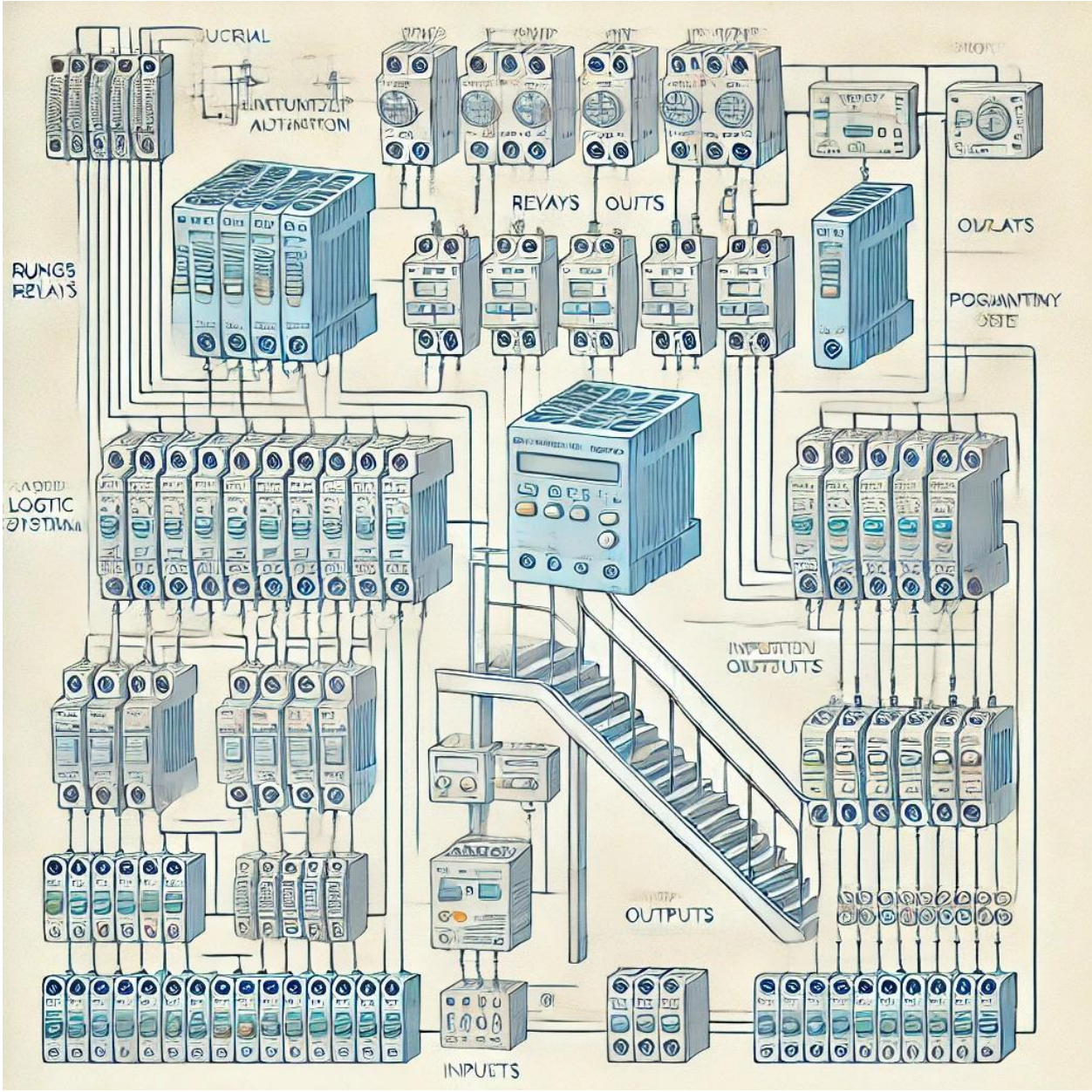
1. **Multiple Choice:** What is the primary function of a PLC?
    - a) To play video games
    - b) To automate electromechanical processes
    - c) To browse the internet
    - d) To send emails
2. **True or False:** PLCs are designed for general-purpose computing.
3. **Fill in the Blanks:** The ____ is the brain of the PLC, and the ____ modules connect the PLC to sensors and actuators.
4. **Short Answer:** Name three programming languages used for PLCs.
5. **Matching:** Match the PLC component with its function:
    - CPU
    - I/O Modules
    - Power Supply
    - a) Connects to sensors and actuators
    - b) Provides voltage
    - c) Executes the program
6. **Essay:** Describe the three main steps in how a PLC works.
7. **Vocabulary:** Define the following terms:
    - Actuator
    - Sensor
8. **Application:** Give an example of how a PLC is used in the automotive industry.
9. **Comparison:** How do PLCs differ from general-purpose computers?
10. **Diagram:** Draw a basic diagram of a PLC system, labeling the key components.

Topic 7. PLC Programming Languages (Ladder Logic, Structured Text, Function Block Diagram)

Programmable Logic Controllers (PLCs) offer a variety of programming languages to suit different applications and programmer preferences. The three most common languages are Ladder Logic (LD), Structured Text (ST), and Function Block Diagram (FBD).

Ladder Logic (LD)

Ladder Logic is a graphical programming language that resembles electrical relay diagrams. It uses contacts (inputs) and coils (outputs) to represent logical operations. LD is widely used for discrete control applications, such as controlling motors, valves, and switches.



Structured Text (ST)

Structured Text is a high-level text-based language that is similar to Pascal or C. It offers a wide range of programming constructs, including loops, conditional statements, and functions. ST is well-suited for complex control algorithms and data processing.

Function Block Diagram (FBD)

Function Block Diagram is a graphical language that uses blocks to represent functions. These blocks can be connected to create complex control systems. FBD is often used for continuous control applications, such as controlling temperature, pressure, and flow.

Comparison of Languages

- **Ladder Logic:** Easy to learn, well-suited for discrete control.
- **Structured Text:** Powerful and flexible, well-suited for complex algorithms.
- **Function Block Diagram:** Graphical and intuitive, well-suited for continuous control.

Choosing a Language

The choice of programming language depends on the specific application and the programmer's experience. Ladder Logic is a good choice for simple applications, while Structured Text is better for complex applications. Function Block Diagram is a good choice for continuous control applications.

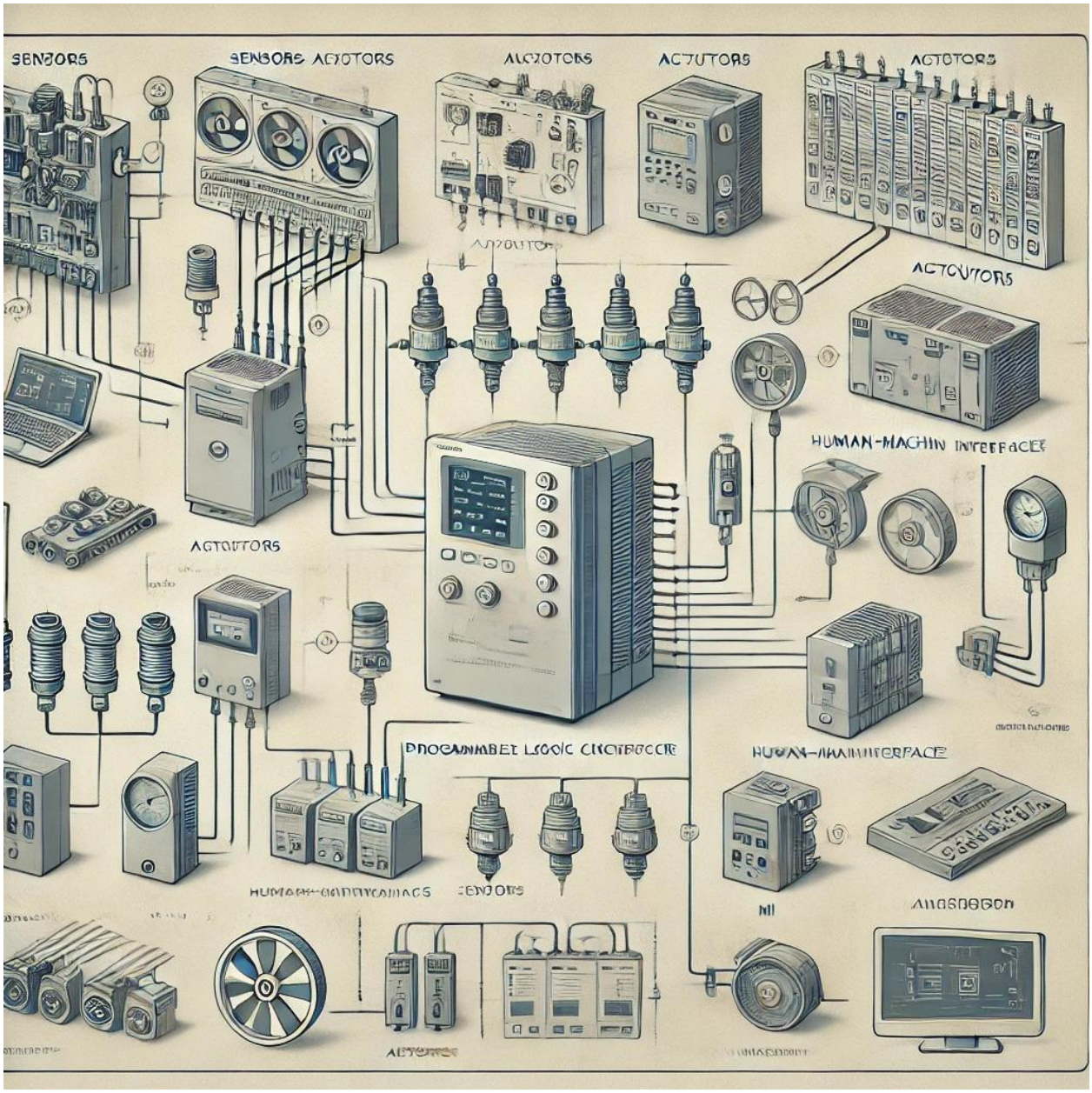
Tasks for Understanding and Vocabulary Practice

1. **Multiple Choice:** Which PLC programming language resembles electrical relay diagrams?
    - a) Structured Text
    - b) Function Block Diagram
    - c) Ladder Logic
    - d) C++
2. **True or False:** Structured Text is a graphical programming language.
3. **Fill in the Blanks:** ____ is a high-level text-based language, and ____ is a graphical language that uses blocks to represent functions.
4. **Short Answer:** Name three PLC programming languages.
5. **Matching:** Match the PLC programming language with its description:
    - Ladder Logic
    - Structured Text
    - Function Block Diagram
    - a) High-level text-based language
    - b) Graphical language that resembles electrical relay diagrams
    - c) Graphical language that uses blocks to represent functions
6. **Essay:** Compare and contrast Ladder Logic, Structured Text, and Function Block Diagram.
7. **Vocabulary:** Define the following terms:
    - Discrete control
    - Continuous control
8. **Application:** Give an example of an application where Structured Text would be the most suitable programming language.
9. **Comparison:** What are the advantages and disadvantages of using Ladder Logic?
10. **Diagram:** Draw a simple example of a Ladder Logic diagram.

Topic 8. PLC Communication Protocols

PLC Communication Protocols

PLC (Programmable Logic Controller) communication protocols are essential for enabling PLCs to exchange data with other devices in industrial automation systems. These protocols define the rules and formats for data transmission, ensuring that different devices can understand and communicate with each other.



Key Concepts:

- **Purpose:**
  - Facilitate data exchange between PLCs and other devices (sensors, actuators, HMIs).
  - Enable interoperability between devices from different manufacturers.
  - Support network communication for centralized control and monitoring.
- **Common Protocols:**
  - **Modbus:** A widely used serial communication protocol known for its simplicity and reliability. Available in Modbus RTU (serial) and Modbus TCP/IP (Ethernet) versions.
  - **PROFIBUS:** A fieldbus standard used in process and factory automation, offering high-speed communication.
  - **EtherNet/IP:** An industrial Ethernet protocol that uses the Common Industrial Protocol (CIP), enabling real-time control over Ethernet networks.
  - **PROFINET:** Another industrial Ethernet protocol designed for real-time communication and high-performance applications.

- **DeviceNet:** A network protocol based on the Controller Area Network (CAN) bus, used for connecting industrial devices.

Key Considerations:

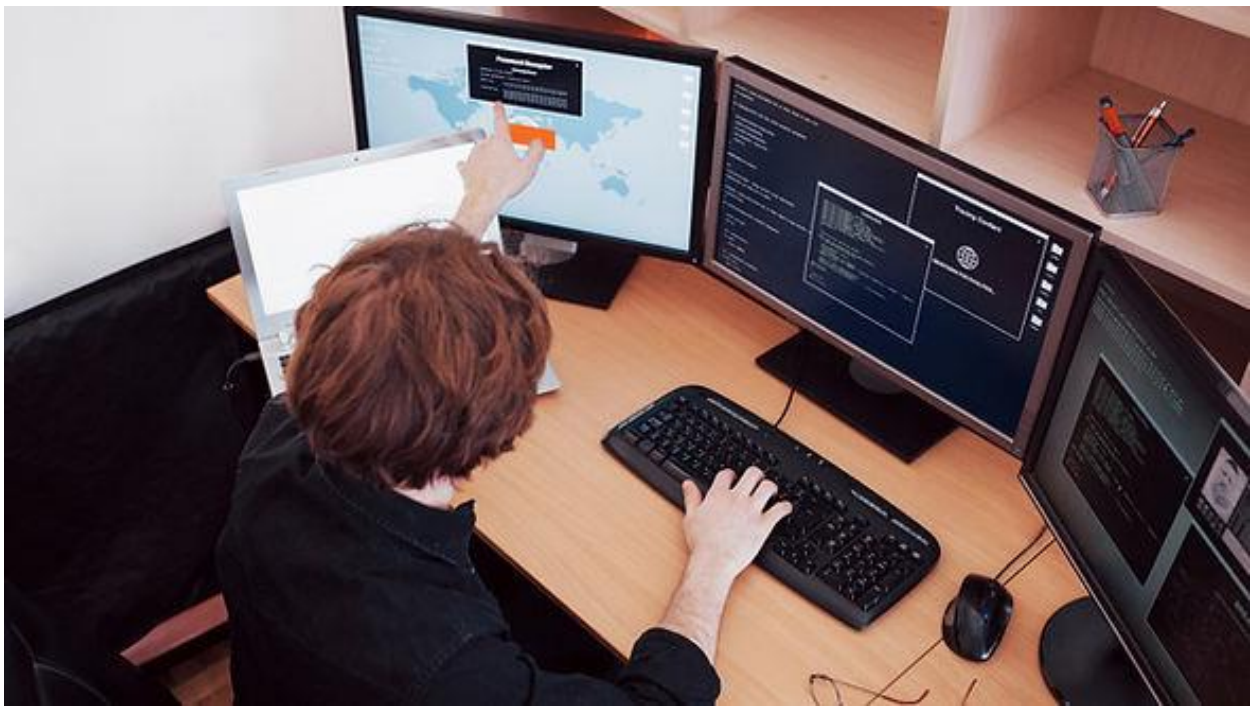
- **Speed and Performance:** Different protocols offer varying data transfer rates.
- **Network Topology:** The physical arrangement of devices in the network.
- **Reliability and Robustness:** The ability to handle errors and maintain communication.
- **Security:** Protecting communication from unauthorized access.

Tasks for Understanding and Vocabulary Practice

1. **Multiple Choice:** What is the primary purpose of PLC communication protocols?
   - a) To play video games.
   - b) To enable data exchange between PLCs and other devices.
   - c) To browse the internet.
   - d) To send emails.
2. **True or False:** Modbus is only available in an Ethernet version.
3. **Fill in the Blanks:** ____ is a widely used serial communication protocol, and ____ is an industrial Ethernet protocol.
4. **Short Answer:** Name three common PLC communication protocols.
5. **Matching:** Match the protocol with its description:
   - Modbus
   - EtherNet/IP
   - PROFIBUS
   - a) Industrial Ethernet protocol using CIP.
   - b) Serial communication protocol.
   - c) Fieldbus standard for process automation.
6. **Essay:** Explain the importance of PLC communication protocols in industrial automation.
7. **Vocabulary:** Define the following terms:
   - Interoperability
   - Fieldbus
8. **Application:** Give an example of an industrial application where EtherNet/IP would be suitable.
9. **Comparison:** Compare and contrast Modbus RTU and Modbus TCP/IP.
10. **Diagram:** Draw a simple diagram illustrating a PLC network with multiple devices connected using a communication protocol.

Topic 9. Real-Time Monitoring and Troubleshooting

In modern industrial automation, real-time monitoring and troubleshooting are essential for ensuring the efficiency, reliability, and safety of processes. Real-time monitoring involves continuously collecting and analyzing data from sensors and devices to provide up-to-date information about the system's performance. Troubleshooting involves identifying and resolving issues that disrupt the normal operation of the system.



Key Aspects of Real-Time Monitoring:

- **Data Acquisition:** Gathering data from sensors, PLCs, and other devices.
- **Visualization:** Presenting data in a user-friendly format, such as dashboards and graphs.
- **Alarm Management:** Setting up alarms to notify operators of abnormal conditions.
- **Data Logging:** Storing data for historical analysis and trend identification.

Key Aspects of Troubleshooting:

- **Fault Detection:** Identifying the presence of a fault or malfunction.
- **Fault Diagnosis:** Determining the root cause of the fault.
- **Fault Resolution:** Implementing corrective actions to restore normal operation.
- **Preventive Maintenance:** Using data analysis to predict and prevent future faults.

Tools and Technologies:

- **Supervisory Control and Data Acquisition (SCADA) systems:** Used for real-time monitoring and control.
- **Human-Machine Interfaces (HMIs):** Provide operators with a graphical interface for monitoring and controlling the system.
- **Programmable Logic Controllers (PLCs):** Used for controlling and monitoring industrial processes.
- **Diagnostic software:** Used for identifying and resolving faults.

Importance:

- Minimizes downtime and maximizes productivity.
- Improves safety by detecting and preventing hazardous conditions.
- Reduces maintenance costs by enabling proactive maintenance.
- Enhances product quality by ensuring consistent process control.

Tasks for Understanding and Vocabulary Practice

1. **Multiple Choice:** What is the primary purpose of real-time monitoring in automation?
    - a) To play video games.
    - b) To provide up-to-date information about system performance.
    - c) To browse the internet.
    - d) To send emails.
2. **True or False:** Troubleshooting involves preventing future faults.
3. **Fill in the Blanks:** ____ systems are used for real-time monitoring and control, and ____ provide operators with a graphical interface.
4. **Short Answer:** Name three key aspects of real-time monitoring.
5. **Matching:** Match the term with its description:
    - SCADA
    - HMI
    - PLC
    - a) Provides a graphical interface for operators.
    - b) Used for controlling industrial processes.
    - c) Used for real-time monitoring and control.
6. **Essay:** Explain the importance of real-time monitoring and troubleshooting in industrial automation.
7. **Vocabulary:** Define the following terms:
    - Fault detection
    - Preventive maintenance
8. **Application:** Give an example of how diagnostic software is used in troubleshooting.
9. **Comparison:** Compare and contrast real-time monitoring and troubleshooting.
10. **Diagram:** Draw a simple diagram illustrating a real-time monitoring system in an automated process.

Topic 10. SCADA and HMI Systems

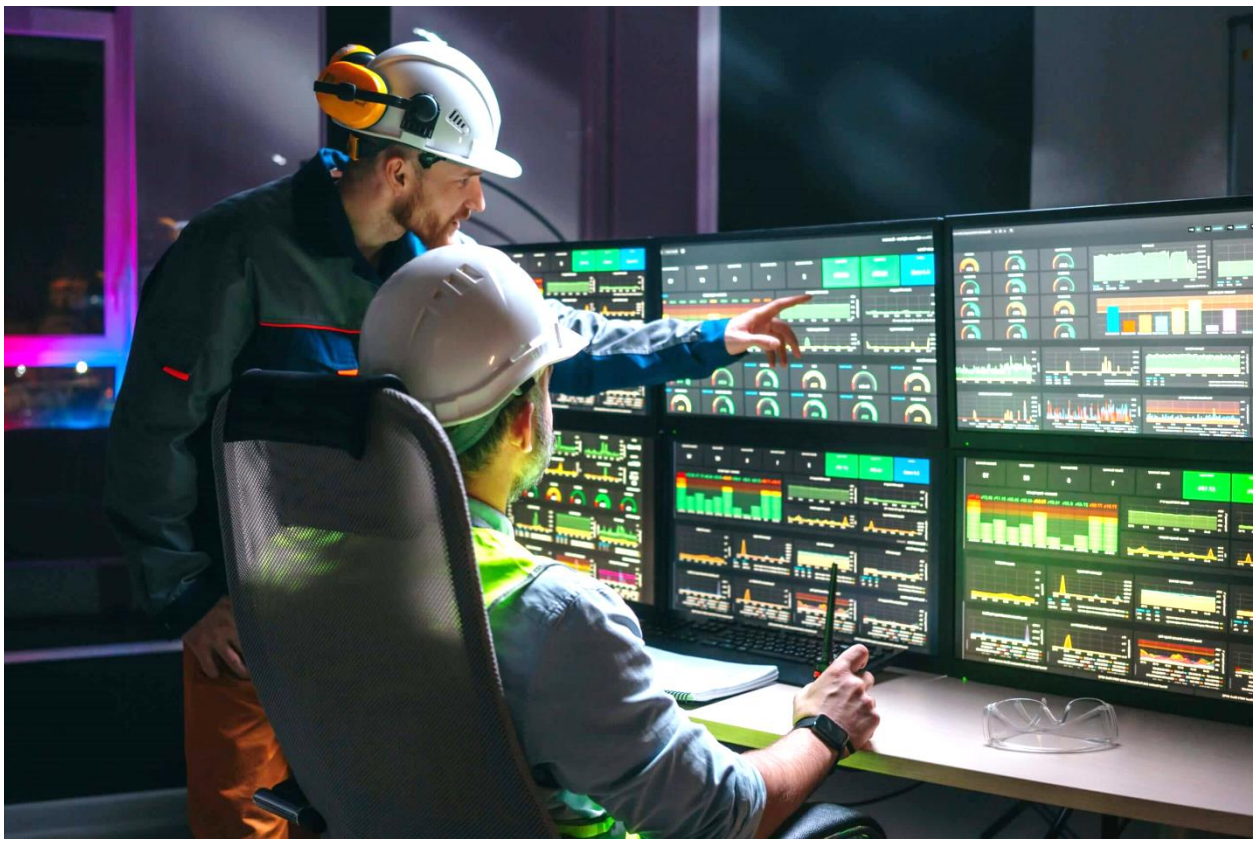
Supervisory Control and Data Acquisition (SCADA) and Human-Machine Interface (HMI) systems are essential components of modern industrial automation. They provide operators with the tools to monitor and control complex processes in real-time.

SCADA Systems:

SCADA systems are used to collect, process, and analyze data from remote devices, such as sensors, PLCs, and other controllers. They provide a centralized platform for monitoring and controlling industrial processes over large geographical areas.

Key Features of SCADA Systems:

- **Data Acquisition:** Gathering data from remote devices.
- **Data Processing:** Analyzing and processing data to generate meaningful information.
- **Data Visualization:** Presenting data in a graphical format, such as dashboards and graphs.
- **Alarm Management:** Notifying operators of abnormal conditions.
- **Historical Data Logging:** Storing data for historical analysis and trend identification.



HMI Systems:

HMI systems provide operators with a graphical interface to interact with the SCADA system and control the industrial process. They allow operators to monitor the process, adjust setpoints, and issue commands to remote devices.

Key Features of HMI Systems:

- **Graphical User Interface (GUI):** Providing a user-friendly interface for operators.
- **Real-time Data Display:** Displaying real-time data from the SCADA system.
- **Control Functions:** Allowing operators to control remote devices.
- **Alarm Display:** Displaying alarms from the SCADA system.
- **Data Entry:** Allowing operators to enter data and setpoints.

Applications:

SCADA and HMI systems are used in a wide range of industries, including:

- Manufacturing
- Oil and gas
- Water and wastewater treatment
- Power generation and distribution
- Transportation

Tasks for Understanding and Vocabulary Practice

1. **Multiple Choice:** What is the primary function of a SCADA system?
    - a) To play video games.

    - b) To collect, process, and analyze data from remote devices.
    - c) To browse the internet.
    - d) To send emails.
2. **True or False:** HMI systems are used to control remote devices.
3. **Fill in the Blanks:** ____ systems provide a centralized platform for monitoring and controlling industrial processes, and ____ systems provide a graphical interface for operators.
4. **Short Answer:** Name three key features of a SCADA system.
5. **Matching:** Match the system with its description:
    - SCADA
    - HMI
    - a) Provides a graphical interface for operators.
    - b) Collects, processes, and analyzes data from remote devices.
6. **Essay:** Explain the importance of SCADA and HMI systems in industrial automation.
7. **Vocabulary:** Define the following terms:
    - Data acquisition
    - Alarm management
8. **Application:** Give an example of how SCADA and HMI systems are used in the oil and gas industry.
9. **Comparison:** Compare and contrast SCADA and HMI systems.
10. **Diagram:** Draw a simple diagram illustrating a SCADA and HMI system in an industrial process.

Robotics and Mechatronics

Topic 11. Introduction to Robotics

Robotics is an interdisciplinary field that integrates computer science, engineering, and mathematics to design, build, and operate robots. A robot is a programmable machine capable of carrying out complex tasks autonomously or with minimal human intervention. Robots are widely used in various industries, including manufacturing, healthcare, space exploration, and even entertainment.

The development of robotics has advanced significantly over the past few decades. Early robots were primarily used in factories for repetitive tasks, such as assembling cars. Modern robots, however, are equipped with artificial intelligence (AI), allowing them to learn from their environment and make decisions. For example, autonomous drones can navigate through obstacles, while robotic arms in surgery can perform precise operations with minimal errors.

One of the key components of a robot is its control system, which consists of hardware and software that enable the robot to function effectively. Sensors play a crucial role in robotics, allowing machines to perceive their surroundings. Cameras, infrared sensors, and ultrasonic sensors help robots detect objects and measure distances, making them more efficient and adaptable to different environments.

Despite the numerous benefits of robotics, there are also challenges and ethical concerns. The increasing reliance on robots in workplaces raises questions about job displacement and the impact on employment. Additionally, ensuring the safety and security of autonomous robots is a major concern, especially in critical applications such as self-driving cars and medical robots.

In the future, robotics is expected to continue evolving, leading to more intelligent and versatile machines. As technology advances, robots may become an integral part of our daily lives,

assisting in household chores, providing companionship, and enhancing productivity in various sectors.

Tasks for Understanding and Vocabulary Practice

1. **Comprehension Questions:**

a) What is robotics?
b) How have robots evolved over the years?
c) Name three industries where robots are commonly used.
d) What role do sensors play in robotics?
e) What are some ethical concerns related to robotics?

2. **True or False:**

a) Robots can only function with direct human control.
b) AI allows robots to learn from their surroundings.
c) Sensors are not important for robots.
d) Autonomous drones cannot avoid obstacles.
e) Robotics is expected to decline in the future.

3. **Match the terms with their definitions:**

a) Artificial Intelligence (AI)
b) Sensor
c) Autonomous
d) Control system
e) Ethics

1. A component that enables a robot to function
2. The ability to operate without human control
3. The study of moral principles and values
4. Technology that enables machines to learn and make decisions
5. A device that detects and responds to stimuli

4. **Fill in the blanks with the correct words:**

a) Robotics combines _____, engineering, and mathematics.
b) Early robots were mainly used in _____ for repetitive tasks.
c) _____ helps robots detect objects and measure distances.
d) Autonomous robots can make _____ on their own.
e) One concern about robotics is job _____.

5. **Synonym Matching:** Find a synonym in the text for each word below:

a) Advancement
b) Crucial
c) Various
d) Precise
e) Integral

6. **Short Essay:** Write a short paragraph (5-6 sentences) explaining how robotics impacts daily life.

7. **Discussion:** In groups, discuss whether the benefits of robotics outweigh the risks. Provide examples.
8. **Word Formation:** Complete the sentences using the correct form of the word in brackets.

   a) The _____ (develop) of robotics has changed many industries.
   b) AI allows robots to operate _____ (autonomy).
   c) Sensors help robots collect _____ (inform).
   d) Ethical concerns about robotics include _____ (secure) issues.
   e) Engineers continue to _____ (improve) robotic systems.

9. **Sentence Scramble:** Rearrange the words to form a correct sentence.

a) AI / robots / learn / helps / from / environment / their.
b) role / play / sensors / important / an / robots / in.
c) displacement / automation / job / cause / can.
d) intelligence / robots / artificial / makes / smarter.
e) concerns / are / ethical / important / robotics / in.

10. **Multiple Choice:**

a) What is one of the main purposes of sensors in robots?

1. To store data
2. To detect objects and measure distances
3. To build the robot's structure
4. To improve battery life

b) Which industry was one of the first to use robots extensively?

1. Education
2. Agriculture
3. Manufacturing
4. Tourism

c) What does AI enable robots to do?

1. Function without electricity
2. Learn and make decisions
3. Replace all human workers
4. Ignore their surroundings

Topic 12. Robot Kinematics and Dynamics

Robot kinematics and dynamics are fundamental concepts in robotics that describe the motion of robots. Kinematics deals with the movement of a robot without considering the forces that cause it, while dynamics focuses on the forces and torques that influence the motion. Understanding these principles is crucial for designing robots that move efficiently and accurately.

Kinematics is divided into two main types: forward kinematics and inverse kinematics. Forward kinematics calculates the position of the robot's end-effector based on given joint parameters, whereas inverse kinematics determines the required joint parameters to achieve a desired

position. These calculations are essential in robotic arms, where precise positioning is necessary for tasks such as assembly, welding, and surgery.

Dynamics, on the other hand, takes into account the forces and torques that affect a robot's movement. It considers aspects like inertia, friction, and gravity. Engineers use dynamic models to simulate robot motion and optimize performance. For example, in humanoid robots, dynamic analysis ensures stability when walking or performing complex actions.

Sensors and control systems play a vital role in implementing kinematics and dynamics in real-world applications. Motion controllers adjust a robot's movements based on kinematic equations, while force sensors help manage dynamic interactions with the environment.

In summary, understanding kinematics and dynamics is essential for designing robots that are both precise and efficient. These principles allow robots to perform complex tasks with accuracy and adaptability, making them valuable tools in industries such as manufacturing, healthcare, and autonomous systems.

Tasks for Understanding and Vocabulary Practice

1. **Comprehension Questions:**

a) What is the main difference between kinematics and dynamics?
b) What are forward and inverse kinematics used for?
c) Why is dynamics important in robotics?
d) How do sensors contribute to robot motion control?
e) Name two industries where robot kinematics and dynamics are crucial.

2. **True or False:**

a) Kinematics deals with forces and torques.
b) Forward kinematics determines the required joint parameters.
c) Dynamics considers inertia, friction, and gravity.
d) Sensors are not used in robot motion control.
e) Robot kinematics is not important in healthcare.

3. **Match the terms with their definitions:**

a) Kinematics
b) Dynamics
c) Forward kinematics
d) Inverse kinematics
e) Torque

1. The study of motion without considering forces
2. The calculation of required joint parameters for a desired position
3. The study of forces affecting motion
4. A force that causes rotation
5. The calculation of an end-effector's position from given joint parameters

4. **Fill in the blanks with the correct words:**

a) Kinematics focuses on _____, while dynamics considers _____.
b) _____ kinematics calculates the position of the robot's end-effector.

c) _____ sensors help robots interact safely with their surroundings.
d) Humanoid robots require dynamic analysis to maintain _____.
e) Engineers use dynamic models to _____ robot movement.

5. **Synonym Matching:** Find a synonym in the text for each word below:

   a) Essential
   b) Precise
   c) Stability
   d) Calculate
   e) Implement

6. **Short Essay:** Write a short paragraph (5-6 sentences) explaining why understanding kinematics and dynamics is important in robotics.
7. **Discussion:** In groups, discuss how kinematics and dynamics affect the design of robotic arms. Provide examples.
8. **Word Formation:** Complete the sentences using the correct form of the word in brackets.

   a) The _____ (analyze) of robot motion requires mathematical models.
   b) Engineers must ensure the _____ (stable) of humanoid robots.
   c) Sensors help robots _____ (adjust) their movements.
   d) The proper use of kinematic equations leads to _____ (accurate) motion.
   e) Understanding dynamics helps _____ (optimize) robot performance.

9. **Sentence Scramble:** Rearrange the words to form a correct sentence.

   a) dynamics / affects / forces / motion / robot.
   b) helps / kinematics / movements / calculate / robot.
   c) forward / determines / kinematics / position / end-effector.
   d) robots / sensors / stability / maintain / help.
   e) engineers / optimize / models / dynamic / use.

10. **Multiple Choice:**

a) What does inverse kinematics calculate?

1. The end-effector's position
2. The required joint parameters
3. The robot's weight
4. The robot's power consumption

b) What factor is considered in robot dynamics?

1. Battery capacity
2. Joint angles only
3. Forces and torques
4. Material color

c) Why is stability important in humanoid robots?

1. To improve their appearance

2. To ensure they do not fall while moving
3. To reduce power consumption
4. To increase their size

Topic 13. Types of Industrial Robots

Industrial robots are widely used in manufacturing and production to improve efficiency, precision, and safety. These robots come in various types, each designed for specific tasks and applications. Understanding the different types of industrial robots is essential for engineers and technicians working in automation.

1. **Articulated Robots** – These robots have rotary joints, providing a high degree of flexibility and movement. They are commonly used in welding, assembly, and material handling.
2. **SCARA Robots** – Selective Compliance Assembly Robot Arm (SCARA) robots are designed for high-speed and precision tasks, such as pick-and-place operations and small-scale assembly.
3. **Cartesian Robots** – Also known as gantry robots, these robots operate in a linear motion along the X, Y, and Z axes. They are widely used in applications that require precise positioning, such as CNC machining and 3D printing.
4. **Delta Robots** – These robots have a spider-like structure and are known for their speed and precision. They are used in food packaging, pharmaceuticals, and electronic component assembly.
5. **Collaborative Robots (Cobots)** – Unlike traditional robots that work in isolated environments, cobots are designed to interact safely with humans. They are used in industries where automation and human collaboration are required, such as medical and automotive sectors.

Each type of industrial robot has unique advantages, making them suitable for different applications. The choice of robot depends on factors such as speed, accuracy, payload capacity, and workspace limitations. As automation technology continues to evolve, industrial robots are

becoming more advanced, contributing to increased productivity and efficiency in various industries.

Tasks for Understanding and Vocabulary Practice

1. **Comprehension Questions:**

a) What are industrial robots used for?
b) How do articulated robots differ from Cartesian robots?
c) What are SCARA robots mainly used for?
d) Why are collaborative robots (cobots) important in certain industries?
e) In which industries are delta robots commonly used?

2. **True or False:** a) Cartesian robots move along rotary joints.

b) SCARA robots are used for high-speed tasks.
c) Delta robots are slow but highly precise.
d) Cobots work in collaboration with humans.
e) Articulated robots are mainly used in food packaging.

3. **Match the terms with their definitions:**

   a) Articulated robot
   b) SCARA robot
   c) Cartesian robot
   d) Delta robot
   e) Collaborative robot

   1. A robot that operates on linear axes
   2. A robot with rotary joints for flexible movement
   3. A robot designed to work safely with humans
   4. A high-speed robot used in food packaging
   5. A robot used in small-scale assembly

4. **Fill in the blanks with the correct words:**

   a) _____ robots have rotary joints for flexible movement.
   b) _____ robots are used in high-speed pick-and-place operations.
   c) _____ robots move along X, Y, and Z axes.
   d) _____ robots can safely work alongside humans.
   e) _____ robots are known for their high-speed performance in packaging.

5. **Synonym Matching:** Find a synonym in the text for each word below:

   a) Precision
   b) Interaction
   c) Structure
   d) Task
   e) Speed

6. **Short Essay:** Write a short paragraph (5-6 sentences) explaining how industrial robots improve manufacturing.

7. **Discussion:** In groups, discuss which type of industrial robot is the most beneficial for the automotive industry and why.
8. **Word Formation:** Complete the sentences using the correct form of the word in brackets.

   a) The _____ (automate) of production lines increases efficiency.
   b) SCARA robots provide high-speed _____ (assemble).
   c) Engineers analyze the _____ (precise) of robotic movements.
   d) The use of cobots improves worker _____ (safe).
   e) The _____ (develop) of robotic systems continues to advance.

9. **Sentence Scramble:** Rearrange the words to form a correct sentence.

   a) robots / used / manufacturing / improve / efficiency / in / are.
   b) pick-and-place / tasks / SCARA / perform / robots.
   c) work / safely / collaborative / humans / with / robots.
   d) industries / delta / high-speed / used / are / robots / in.
   e) accuracy / Cartesian / provide / positioning / robots.

10. **Multiple Choice:**

a) What type of robot moves along linear axes?

1. Articulated robot
2. Cartesian robot
3. Delta robot
4. SCARA robot

b) Which type of robot is commonly used in food packaging?

1. SCARA robot
2. Delta robot
3. Articulated robot
4. Cartesian robot

c) What is the main advantage of collaborative robots?

1. They move faster than other robots.
2. They are highly specialized for industrial tasks.
3. They can work safely alongside humans.
4. They require no maintenance.

Topic 14. End Effectors and Grippers

End effectors are crucial components of robotic systems that interact with objects in the environment. They are attached to the end of a robotic arm and are responsible for performing specific tasks such as gripping, welding, painting, or assembling parts. The functionality of an end effector depends on its design and the application for which it is used.

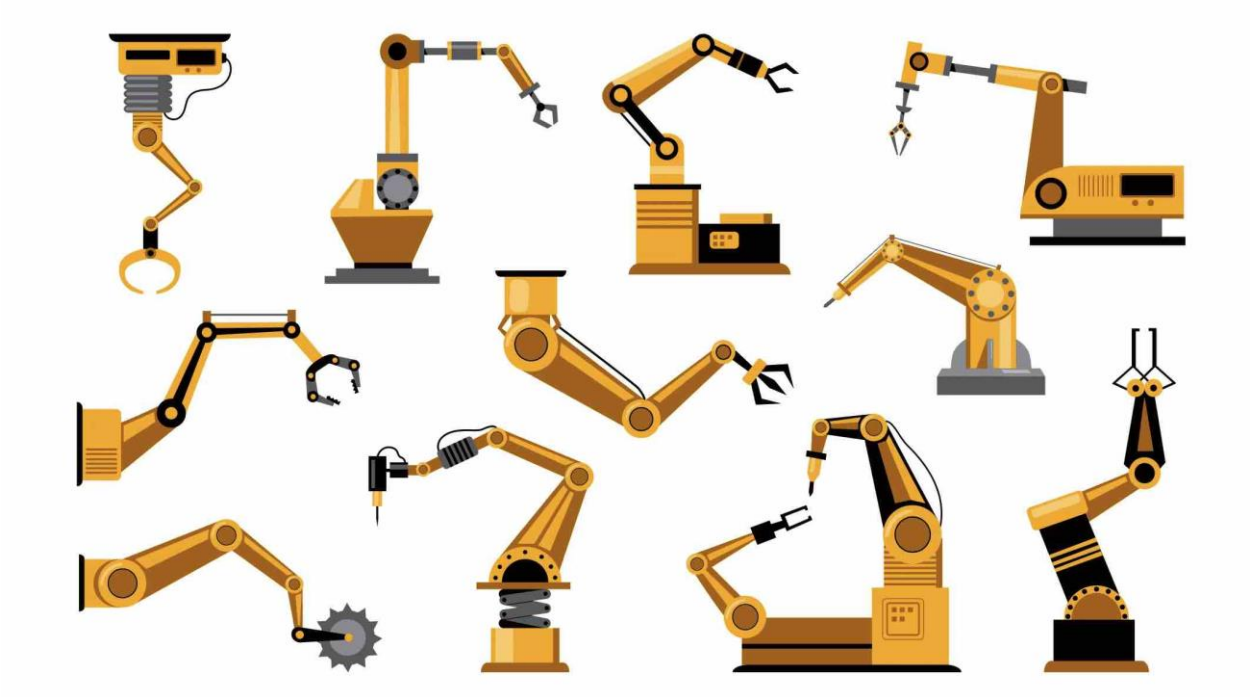
One of the most common types of end effectors is the robotic gripper. Grippers are used to grasp, hold, and manipulate objects. They come in various designs, including mechanical grippers, vacuum grippers, magnetic grippers, and adhesive grippers. Mechanical grippers use fingers or

claws to grip objects, while vacuum grippers use suction cups powered by air pressure. Magnetic grippers are used for handling metallic objects, and adhesive grippers rely on sticky surfaces to hold items securely.

End effectors can also include specialized tools such as welding torches, screwdrivers, and cutting devices. These tools enable robots to perform precise operations in manufacturing, construction, and medical applications. For example, robotic arms in the automotive industry use welding torches to join metal parts, while robotic surgeons use delicate tools for performing operations.

The selection of an appropriate end effector depends on several factors, including the type of object being handled, the required precision, and the environmental conditions. Advanced end effectors incorporate sensors and artificial intelligence to adapt to different tasks, improving efficiency and versatility.

As technology advances, end effectors continue to evolve, allowing robots to perform more complex and delicate operations. Their development enhances automation, making robotic systems more effective in industries ranging from logistics to healthcare.



Tasks for Understanding and Vocabulary Practice

1. **Comprehension Questions:**

a) What is the function of an end effector?
b) Name four types of robotic grippers and their working principles.
c) How do vacuum grippers hold objects?
d) In which industries are specialized end effectors commonly used?
e) Why do some advanced end effectors include sensors and artificial intelligence?

2. **True or False:**

a) End effectors are always used for gripping objects.
b) Magnetic grippers can hold non-metallic objects.
c) Vacuum grippers use suction cups.
d) Robotic arms in surgery use specialized tools as end effectors.
e) End effectors cannot be customized for specific tasks.

3. **Match the terms with their definitions:**

   a) End effector
   b) Mechanical gripper
   c) Vacuum gripper
   d) Magnetic gripper
   e) Adhesive gripper

   1. Uses air pressure to hold objects
   2. A device at the end of a robotic arm used for tasks
   3. Uses magnetic force to manipulate objects
   4. Uses fingers or claws to grip items
   5. Uses a sticky surface to grasp objects

4. **Fill in the blanks with the correct words:**

   a) End effectors are attached to the _____ of a robotic arm.
   b) _____ grippers use fingers or claws to hold objects.
   c) _____ grippers rely on suction cups for gripping.
   d) Welding torches and cutting devices are examples of _____ end effectors.
   e) The choice of an end effector depends on the object's _____ and handling requirements.

5. **Synonym Matching:** Find a synonym in the text for each word below:

   a) Precision
   b) Manipulate
   c) Delicate
   d) Enhance
   e) Versatility

6. **Short Essay:** Write a short paragraph (5-6 sentences) explaining why end effectors are important in robotics and how they improve automation.
7. **Discussion:** In groups, discuss which type of gripper would be most useful in a warehouse and why.
8. **Word Formation:** Complete the sentences using the correct form of the word in brackets.

   a) Robotic arms improve _____ (efficient) in production lines.
   b) The _____ (select) of the correct end effector is crucial for automation.
   c) Sensors help robots _____ (adaptation) to different tasks.
   d) Welding torches enable robots to perform _____ (precise) metalwork.
   e) The _____ (develop) of smart end effectors is improving robotic technology.

9. **Sentence Scramble:** Rearrange the words to form a correct sentence.

a) robots / use / to / end effectors / objects / handle.
b) magnetic / for / grippers / are / metallic / used / objects.
c) automation / improves / efficiency / robotics / in.
d) vacuum / suction / grippers / rely / on.
e) delicate / surgery / robotic / end effectors / in / used / are.

10. **Multiple Choice:**

a) Which type of gripper uses air pressure to hold objects?
1. Mechanical gripper
2. Magnetic gripper
3. Vacuum gripper
4. Adhesive gripper
b) What is a key factor in selecting an end effector?
1. The robot's color
2. The type of object being handled
3. The robot's weight
4. The factory temperature
c) Why do some end effectors have sensors?
1. To improve adaptability and precision
2. To reduce power consumption
3. To make the robot move faster
4. To change the robot's appearance

Topic 15. Robot Motion Planning and Path Control

Robot motion planning and path control are essential aspects of robotics that determine how a robot moves from one point to another while avoiding obstacles and optimizing efficiency. These processes involve algorithms, sensors, and control systems that enable robots to navigate complex environments.

Motion planning is the process of determining a collision-free path for a robot to follow. It requires knowledge of the robot's kinematics, workspace, and environmental constraints. There are different types of motion planning algorithms, including:

- **Graph-based algorithms** (e.g., A* and Dijkstra's algorithm), which search for the shortest or most efficient path in a mapped environment.
- **Sampling-based algorithms** (e.g., Rapidly-exploring Random Trees (RRT) and Probabilistic Roadmaps (PRM)), which generate random samples to explore possible paths.
- **Optimization-based methods**, which use mathematical functions to improve movement efficiency.

Path control ensures that a robot follows the planned trajectory accurately. It involves adjusting the robot's speed, direction, and joint movements in real time. Some common path control methods include:

- **PID (Proportional-Integral-Derivative) controllers**, which continuously correct errors in motion.
- **Feedforward control**, which predicts motion adjustments before errors occur.
- **Model predictive control (MPC)**, which considers future states to optimize motion.

Applications of motion planning and path control include autonomous vehicles, robotic arms in manufacturing, and service robots in warehouses. These techniques enhance precision, safety, and operational efficiency.

As robotics technology advances, motion planning and path control continue to improve, allowing robots to operate more autonomously in dynamic environments.

Tasks for Understanding and Vocabulary Practice

1. **Comprehension Questions:**

a) What is the purpose of motion planning in robotics?
b) Name three types of motion planning algorithms and briefly describe them.
c) How does path control help a robot execute its movements?
d) What role do PID controllers play in robot path control?
e) In which industries is robot motion planning commonly applied?

2. **True or False:**

a) Motion planning is only used for robotic arms.
b) The A* algorithm is an example of a graph-based algorithm.
c) Sampling-based methods use random samples to find paths.
d) Feedforward control predicts motion errors in advance.
e) Path control does not involve real-time adjustments.

3. **Match the terms with their definitions:**

a) Motion planning
b) Path control
c) PID controller
d) RRT algorithm
e) Feedforward control

1. Predicts motion errors before they happen
2. Finds a collision-free path for a robot
3. Generates random samples for motion planning
4. Adjusts robot movements to follow a planned path
5. Corrects motion errors using proportional, integral, and derivative components

4. **Fill in the blanks with the correct words:**

a) _____ planning helps a robot find a path while avoiding obstacles.
b) _____ controllers adjust movements in real time to reduce errors.
c) Graph-based algorithms include _____ and Dijkstra's algorithm.
d) The _____ algorithm explores paths using random sampling.
e) Path control ensures that robots follow the planned _____ accurately.

5. **Synonym Matching:** Find a synonym in the text for each word below:

a) Navigation
b) Adjust
c) Efficiency

d) Optimize
e) Collision-free

6. **Short Essay:** Write a short paragraph (5-6 sentences) explaining why motion planning and path control are important in autonomous robots.
7. **Discussion:** In groups, discuss the challenges of robot motion planning in dynamic environments and possible solutions.
8. **Word Formation:** Complete the sentences using the correct form of the word in brackets.

a) Motion _____ (plan) helps robots navigate environments.
b) The _____ (control) of robot movement ensures precision.
c) Engineers use algorithms for _____ (optimize) robot paths.
d) Autonomous robots require real-time _____ (adjust) to their movement.
e) The development of new _____ (technology) improves robot navigation.

9. **Sentence Scramble:** Rearrange the words to form a correct sentence.

a) robots / motion / paths / plan / their / must.
b) follow / control / path / ensures / accuracy.
c) PID / adjusts / real-time / controllers / errors / in.
d) avoids / planning / collision / motion.
e) optimization-based / paths / improves / efficiency.

10. **Multiple Choice:**

a) Which algorithm is an example of a graph-based method?

1. RRT
2. A*
3. PRM
4. MPC

b) What does a PID controller do?

1. Predicts future motion errors
2. Adjusts movements using three control components
3. Uses sampling-based planning
4. Avoids obstacles using sensors

c) What is the main goal of motion planning?

1. To reduce robot power consumption
2. To create a collision-free path
3. To increase robot size
4. To improve battery life

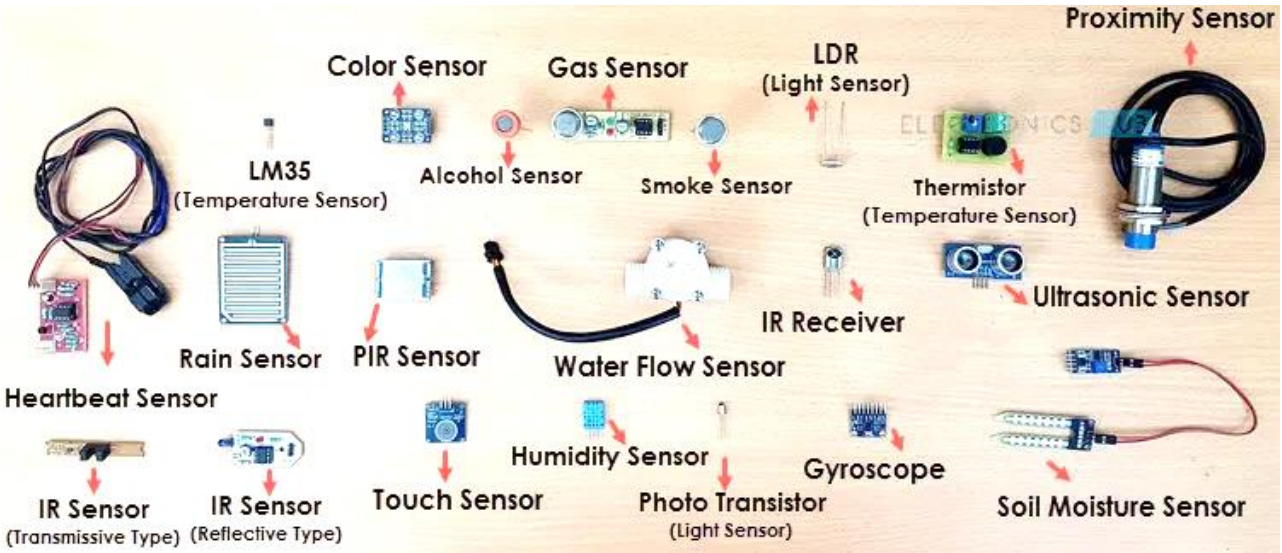
Industrial Sensors and Measurement Systems

Topic 16. Types of Sensors (Proximity, Optical, Temperature, Pressure, etc.)

Sensors are essential components in robotics and automation, allowing machines to perceive and interact with their surroundings. Different types of sensors are used to detect various physical properties such as distance, light, temperature, and pressure. Below are some of the most common types of sensors and their applications.

1. **Proximity Sensors**: These sensors detect the presence or absence of an object without physical contact. They are commonly used in industrial robots for object detection and positioning. Types of proximity sensors include inductive, capacitive, and ultrasonic sensors.
2. **Optical Sensors**: Optical sensors use light to detect objects and measure distances. Examples include infrared sensors, laser rangefinders, and photoelectric sensors. These sensors are widely used in robotics, automation, and security systems.
3. **Temperature Sensors**: These sensors measure temperature changes and are used in applications such as industrial processes, medical devices, and environmental monitoring. Common types include thermocouples, resistance temperature detectors (RTDs), and infrared temperature sensors.
4. **Pressure Sensors**: Pressure sensors measure the force exerted by a liquid or gas. They are used in various fields, including automotive systems, weather monitoring, and medical devices such as blood pressure monitors.
5. **Force and Tactile Sensors**: These sensors measure force, weight, and pressure applied to a surface. They are crucial in robotic arms, prosthetic devices, and touch-sensitive applications like smartphones and gaming controllers.
6. **Gas Sensors**: Gas sensors detect the presence of gases such as carbon monoxide, methane, or oxygen. They are used in environmental monitoring, industrial safety, and medical applications.
7. **Motion Sensors**: Motion sensors detect movement and are commonly used in security systems, gaming devices, and autonomous robots. Examples include accelerometers and gyroscopes.

Each type of sensor plays a vital role in improving automation, safety, and efficiency across various industries. As sensor technology advances, robots and smart systems become more capable of interacting intelligently with their environments.



Tasks for Understanding and Vocabulary Practice

1. **Comprehension Questions:** a) What is the main function of sensors in robotics? b) Name three types of proximity sensors and explain their differences. c) How do optical sensors detect objects? d) In what applications are temperature sensors commonly used? e) Why are pressure sensors important in medical devices?
2. **True or False:** a) Proximity sensors require physical contact to detect objects. b) Infrared sensors belong to the category of optical sensors. c) Thermocouples are a type of temperature sensor. d) Pressure sensors only measure solid materials. e) Gas sensors can detect dangerous gases in industrial environments.
3. **Match the terms with their definitions:**

   a) Optical sensor
   b) Proximity sensor
   c) Pressure sensor
   d) Motion sensor
   e) Gas sensor

   1. Detects movement or changes in position
   2. Measures force exerted by liquids or gases
   3. Uses light to detect objects or distances
   4. Detects objects without physical contact
   5. Identifies the presence of specific gases
4. **Fill in the blanks with the correct words:**

a) _____ sensors measure the force exerted by gases or liquids.
b) A laser rangefinder is an example of an _____ sensor.
c) Thermocouples and RTDs are types of _____ sensors.
d) _____ sensors are used to detect carbon monoxide in the air.
e) Gaming controllers often use _____ sensors to detect movement.

5. **Synonym Matching:** Find a synonym in the text for each word below:

   a) Detect
   b) Measure
   c) Presence
   d) Smart
   e) Capable

6. **Short Essay:** Write a short paragraph (5-6 sentences) explaining how different types of sensors help improve automation and safety in industries.
7. **Discussion:** In groups, discuss which type of sensor is the most important in everyday life and why.
8. **Word Formation:** Complete the sentences using the correct form of the word in brackets. a) Sensors improve the _____ (efficient) of robotic systems.
   b) The correct _____ (select) of sensors depends on the application.
   c) Gas sensors provide real-time _____ (detect) of harmful gases.
   d) Advances in sensor _____ (technology) allow robots to interact better with the environment.
   e) Optical sensors are used in industrial _____ (automate) systems.
9. **Sentence Scramble:** Rearrange the words to form a correct sentence.

a) robots / sensors / use / detect / to / objects.
b) optical / detect / sensors / light / using / objects.
c) safety / sensors / improve / industrial.
d) used / in / are / medical / temperature / devices / sensors.
e) gas / harmful / detect / environments / sensors / in / gases.

10. Multiple Choice:

a) Which sensor type measures changes in temperature?

1. Optical sensor
2. Temperature sensor
3. Proximity sensor
4. Motion sensor

b) What is an example of a motion sensor?

1. Thermocouple
2. Gyroscope
3. Photoelectric sensor
4. Capacitive sensor

c) Where are gas sensors commonly used?

1. In automotive engines
2. In security cameras
3. In robotic arms
4. In gaming consoles

Topic 17. Data Acquisition Systems (DAQ)

Data Acquisition Systems (DAQ) are essential for collecting, measuring, and analyzing data from various physical phenomena. These systems are widely used in industrial automation, scientific research, and engineering applications. A DAQ system typically consists of sensors, signal conditioning hardware, data acquisition devices, and a computer or software for data processing.

Components of a DAQ System:

1. **Sensors** – Convert physical parameters such as temperature, pressure, or force into electrical signals.
2. **Signal Conditioning Hardware** – Amplifies, filters, and converts signals to a format suitable for processing.
3. **Data Acquisition Device (DAQ Hardware)** – Digitizes analog signals and transfers them to a computer.
4. **Computer and Software** – Processes, visualizes, and analyzes collected data.

Types of DAQ Systems:

- **Standalone DAQ Systems** – Operate independently without requiring a computer.

- **PC-Based DAQ Systems** – Use a computer to acquire and process data, often connected via USB or PCI interfaces.
- **Networked DAQ Systems** – Collect data remotely and transmit it over a network for analysis.

Applications of DAQ Systems:

- **Industrial Automation** – Monitoring and controlling machinery.
- **Scientific Research** – Recording experimental data in laboratories.
- **Environmental Monitoring** – Measuring temperature, humidity, and air quality.
- **Medical Diagnostics** – Collecting biological signals like ECG or EEG.
- **Automotive Testing** – Analyzing engine performance and safety parameters.

With advancements in technology, modern DAQ systems offer higher accuracy, faster data rates, and improved connectivity, making them indispensable in various fields.

Tasks for Understanding and Vocabulary Practice

1. **Comprehension Questions:**

a) What are the main components of a DAQ system?
b) How do sensors contribute to data acquisition?
c) What is the function of signal conditioning hardware?
d) Describe two types of DAQ systems and their applications.
e) Why are DAQ systems important in industrial automation?

2. **True or False:**

a) DAQ systems are only used in scientific research.
b) Signal conditioning hardware converts physical parameters directly into digital signals. c) PC-based DAQ systems require a computer for data processing.
d) Networked DAQ systems allow remote data collection.
e) Automotive testing does not require DAQ systems.

3. **Match the terms with their definitions:**

   a) DAQ device
   b) Sensors
   c) Signal conditioning
   d) PC-based DAQ
   e) Networked DAQ

   1. Converts physical parameters into electrical signals.
   2. Digitizes and transfers data to a computer.
   3. Prepares signals for proper measurement.
   4. Uses a computer to process acquired data.
   5. Transmits collected data over a network.

4. **Fill in the blanks with the correct words:**

a) A DAQ system consists of sensors, _____, a DAQ device, and a computer.
b) _____ DAQ systems work independently without a computer.
c) The main role of _____ is to prepare signals for measurement.

d) _____ are used to convert temperature, pressure, or force into electrical signals.
e) DAQ systems are widely used in _____ automation.

5. **Synonym Matching:** Find a synonym in the text for each word below:

   a) Measure
   b) Record
   c) Device
   d) Analyze
   e) Transmit

6. **Short Essay:** Write a short paragraph (5-6 sentences) explaining the role of DAQ systems in scientific research and industry.
7. **Discussion:** In groups, discuss how advancements in DAQ technology improve efficiency in modern applications.
8. **Word Formation:** Complete the sentences using the correct form of the word in brackets.

   a) The correct _____ (select) of sensors improves data accuracy.
   b) Engineers use DAQ systems for _____ (analyze) experimental data.
   c) The latest _____ (develop) in DAQ systems enhance real-time monitoring.
   d) _____ (measure) of environmental parameters is crucial in research.
   e) Modern DAQ systems improve _____ (efficient) in industrial processes.

9. **Sentence Scramble:** Rearrange the words to form a correct sentence.

   a) collect / DAQ / real-time / data / systems.
   b) sensors / convert / parameters / signals / into / electrical.
   c) industrial / used / DAQ / systems / automation / in / are.
   d) improve / monitoring / signal / data / conditioning.
   e) allows / remote / DAQ / data / collection / networked.

10. **Multiple Choice:**

a) What is the purpose of signal conditioning in DAQ systems?

1. To convert data into digital format
2. To amplify, filter, and adjust signals
3. To store acquired data
4. To visualize measurements

b) Which DAQ system operates without a computer?

1. PC-based DAQ
2. Networked DAQ
3. Standalone DAQ
4. Wireless DAQ

c) Where are DAQ systems commonly used?

1. In industrial automation
2. In video gaming

3. In cooking appliances
4. In music production

Topic 18. Signal Conditioning and Filtering

Signal conditioning is a crucial process in electronics and instrumentation, ensuring that signals are properly prepared for further processing. It involves various techniques such as amplification, attenuation, isolation, and filtering to improve signal quality and reliability.

One of the key aspects of signal conditioning is amplification, which increases the strength of a weak signal. This is particularly important in sensors, where signals may be too small to be processed directly. Conversely, attenuation reduces signal strength to match the input range of the next processing stage, preventing distortion and overloading.

Another essential function of signal conditioning is isolation. Electrical isolation protects sensitive equipment and operators from high-voltage signals and minimizes noise interference. Isolation techniques include transformers, optical couplers, and capacitive isolation.

Filtering is another fundamental aspect of signal conditioning. Filters are used to remove unwanted frequencies and noise from signals. There are several types of filters, including low-pass, high-pass, band-pass, and notch filters. Low-pass filters allow low frequencies to pass while blocking high frequencies, which is useful in reducing high-frequency noise. High-pass filters do the opposite, removing low-frequency components such as DC offsets. Band-pass filters allow only a specific frequency range to pass, while notch filters remove a narrow frequency band, often used to eliminate power line interference.

Modern signal conditioning circuits may also include analog-to-digital conversion, linearization, and temperature compensation to ensure accurate data acquisition. These techniques play a vital role in applications such as medical instrumentation, industrial automation, and communication systems.

Tasks for Understanding and Vocabulary Practice

1. True/False Questions:

a) Amplification decreases the strength of a signal.
b) Attenuation is used to protect signals from high voltage.
c) A band-pass filter removes all frequency components from a signal.

2. Multiple Choice Questions:

a) Which of the following components is used for electrical isolation?
- A) Transformer
- B) Resistor
- C) Capacitor
- D) Diode

b) What type of filter removes low-frequency components?
- A) High-pass filter
- B) Low-pass filter
- C) Band-pass filter
- D) Notch filter

3. Fill in the Blanks:

a) _____ increases the strength of weak signals.
b) A _____ filter removes a narrow frequency band from a signal.

4. Match the Following:

a) Amplification - (1) Reduces signal strength
b) Attenuation - (2) Removes unwanted noise
c) Filtering - (3) Increases signal strength

5. Define the following terms in your own words:

a) Signal conditioning
b) Isolation
c) Filtering

6. Explain the importance of signal conditioning in data acquisition systems.

7. Describe the difference between low-pass and high-pass filters.

8. Provide an example of an application where isolation is essential and explain why.

9. Discuss the role of analog-to-digital conversion in modern signal conditioning.

10. Imagine you are designing a sensor system for an industrial application. What types of signal conditioning techniques would you use and why?

Topic 19. Sensor Fusion in Robotics

Sensor fusion is a critical technology in modern robotics, allowing robots to integrate data from multiple sensors to achieve more accurate perception and decision-making. By combining information from different sensors, robots can overcome the limitations of individual sensors and improve their ability to navigate and interact with their environment.

Different types of sensors provide various kinds of data. For example, cameras capture visual information, LiDAR measures distances using laser beams, and inertial measurement units (IMUs) detect motion and orientation. While each sensor has its advantages, it also has weaknesses. Cameras, for instance, struggle in low-light conditions, while LiDAR can be affected by reflective surfaces. By fusing data from multiple sensors, robots can compensate for these weaknesses and generate a more reliable understanding of their surroundings.

There are several methods of sensor fusion, including complementary, redundant, and cooperative fusion. Complementary fusion combines data from sensors that provide different but related information. Redundant fusion uses multiple sensors of the same type to improve accuracy and reliability. Cooperative fusion integrates different sensor types to create a richer dataset.

A common approach to sensor fusion is the Kalman filter, which helps estimate the true state of a system by combining sensor data and reducing noise. Another method is the particle filter, often used in robotics for localization and mapping. Machine learning techniques are also

increasingly applied to sensor fusion, enabling robots to learn from vast amounts of data and improve their decision-making processes.

Sensor fusion is widely used in autonomous vehicles, industrial robots, and medical robotics. For instance, self-driving cars rely on sensor fusion to detect obstacles, recognize traffic signs, and navigate safely. In industrial settings, robotic arms use sensor fusion to perform precise assembly tasks, while in healthcare, robotic-assisted surgery benefits from enhanced precision and real-time feedback through sensor integration.

Tasks for Understanding and Vocabulary Practice

1. True/False Questions:
a) Sensor fusion helps robots use only one type of sensor.
b) LiDAR is effective in all lighting conditions.
c) The Kalman filter is used to improve sensor accuracy.

2. Multiple Choice Questions:
a) Which of the following is NOT a type of sensor fusion?
- A) Complementary fusion
- B) Redundant fusion
- C) Conflicting fusion
- D) Cooperative fusion

b) What is the main benefit of sensor fusion?
- A) It increases sensor cost
- B) It improves data accuracy and reliability
- C) It eliminates the need for sensors
- D) It slows down data processing

3. Fill in the Blanks:
a) _____ measures distances using laser beams.
b) The _____ filter is a common algorithm used for sensor fusion.

4. Match the Following:
a) Cameras - (1) Detect motion and orientation
b) LiDAR - (2) Captures visual information
c) IMU - (3) Measures distances using lasers

5. Define the following terms in your own words:
a) Sensor fusion
b) Kalman filter
c) Redundant fusion

6. Explain why sensor fusion is important in robotics.

7. Describe the difference between complementary and redundant sensor fusion.

8. Provide an example of how sensor fusion is used in autonomous vehicles.

9. Discuss the role of machine learning in sensor fusion.

10. Imagine you are designing a robotic system for a warehouse. What sensors would you use, and how would you apply sensor fusion to improve efficiency?

Topic 20. Smart Sensors and IoT Integration

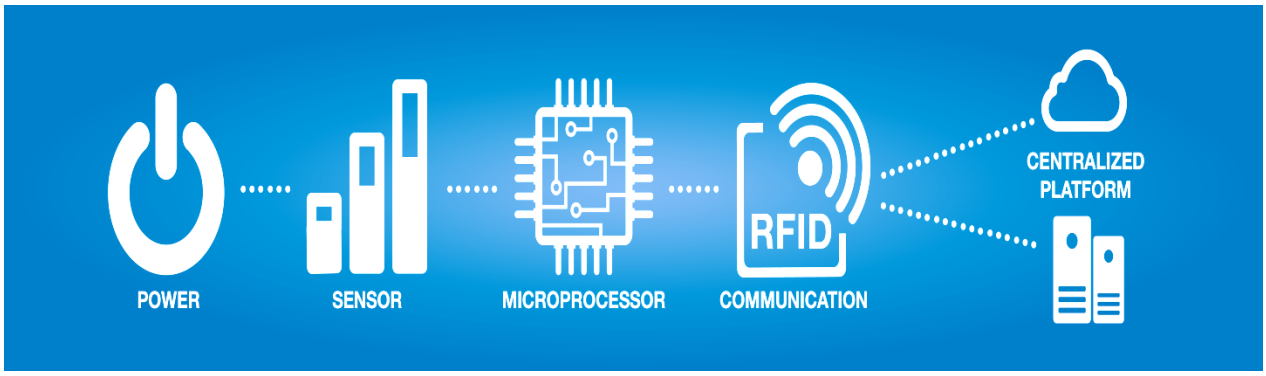
Smart sensors play a crucial role in the development of the Internet of Things (IoT). These sensors are equipped with advanced processing capabilities, allowing them to collect, analyze, and transmit data efficiently. Unlike traditional sensors, smart sensors can filter out noise, process information locally, and communicate with other devices over a network.

One of the key advantages of smart sensors is their ability to enhance automation and real-time decision-making. They are widely used in industries such as healthcare, manufacturing, agriculture, and smart homes. For example, in healthcare, wearable devices with smart sensors can monitor heart rate, oxygen levels, and body temperature, sending alerts in case of abnormal readings. In agriculture, smart sensors help farmers monitor soil moisture, weather conditions, and crop health, optimizing irrigation and improving yields.

IoT integration enables smart sensors to connect to cloud platforms, where data is processed and analyzed on a large scale. This connectivity allows remote monitoring, predictive maintenance, and efficient resource management. For instance, in smart cities, IoT-integrated sensors help manage traffic flow, monitor air quality, and detect leaks in water supply systems.

Security and data privacy are major challenges in IoT-based smart sensor networks. Since these sensors constantly collect and transmit data, they are vulnerable to cyber threats. Strong encryption, authentication protocols, and secure cloud storage solutions are essential to protect sensitive information.

As IoT technology continues to evolve, smart sensors will become even more intelligent, supporting edge computing and AI-driven analytics. This will lead to greater efficiency, sustainability, and automation across various industries.



Tasks for Understanding and Vocabulary Practice

1. True/False Questions:
a) Smart sensors cannot process data locally.
b) IoT integration allows remote monitoring and predictive maintenance.
c) Smart sensors are only used in manufacturing.

2. Multiple Choice Questions:
a) Which of the following is a key benefit of smart sensors?
- A) They increase manual labor

- B) They enhance automation and real-time decision-making
- C) They decrease connectivity
- D) They work only in isolated environments

b) What is a major challenge in IoT-based smart sensor networks?
- A) Limited applications
- B) Security and data privacy risks
- C) Lack of automation
- D) High energy consumption

3. Fill in the Blanks:
a) _____ sensors can filter noise and process data locally.
b) _____ helps connect smart sensors to cloud platforms for large-scale data analysis.

4. Match the Following:
a) Wearable devices - (1) Monitor soil moisture
b) Smart cities - (2) Detect air quality and traffic flow
c) Agriculture - (3) Measure heart rate and body temperature

5. Define the following terms in your own words:
a) Smart sensor
b) IoT integration
c) Predictive maintenance

6. Explain how smart sensors improve automation in industries.

7. Describe the role of smart sensors in healthcare applications.

8. Provide an example of how IoT-integrated sensors are used in smart cities.

9. Discuss the importance of security measures in IoT-based sensor networks.

10. Imagine you are designing a smart home system. What smart sensors would you include, and how would they improve daily life?

Навчально-методичне видання

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