ROBOT

Learning Outcomes

- Introduction to Robot
- Types of Robot
- Autonomous & Semi-Autonomous Robot
- Role of Sensor & AI in Robotics

A robot is a smart machine designed to perform tasks on its own or with some human help. The study of robots is called robotics, which combines mechanical engineering, electronics, and computer programming. Robots have different parts that help them work, such as a body for movement, sensors to sense the environment, motors to perform actions, and a control system to make decisions. Some robots follow fixed instructions, while others use Artificial Intelligence (AI) to learn and improve their performance over time.

Robots come in different types based on how they work. Autonomous robots can operate on their own without human control, like self-driving cars and robotic vacuum cleaners. Semi-autonomous robots need human guidance for some tasks, like drones controlled by a pilot. There are also humanoid robots that look and act like humans and industrial robots that help in factories by assembling products.

Robots are used in many fields to make work easier and faster. In factories, they help assemble and package products. In hospitals, they assist in surgeries and patient care. In farming, robots are used for planting and harvesting crops. In space exploration, robots explore planets where humans cannot go. They are also used in defense and security for tasks like surveillance and bomb disposal.

As technology improves, robots are becoming smarter and more helpful in daily life. From home assistants to self-driving cars, robots are making tasks easier, safer, and more efficient. In the future, they will play an even bigger role in industries and everyday activities.

What is a Robot?

A **robot** is a machine that can do tasks on its own. It can be programmed to follow instructions or use **Artificial Intelligence (AI)** to make decisions. Robots help humans in many ways, from doing simple household chores to handling complex jobs in factories and science labs.

Characteristics of a Robot

For a machine to be called a robot, it should have:

- **Sensing Ability** – Robots use sensors to understand their surroundings. For example, cameras help them see, and temperature sensors help them feel heat or cold.
- **Processing Unit (Brain)** – A robot has a small computer inside (a processor or microcontroller) that helps it think and make decisions based on what it senses.
- **Movement (Actuators)** – Robots move using motors, wheels, arms, or legs to perform different tasks.
- **Power Source** – Robots need energy to work, which can come from batteries, solar panels, or electricity.
- **Programming** – Robots follow instructions written in code. This tells them what to do and how to react in different situations.

How Do Robots Work?

Robots work by following a simple three-step process:
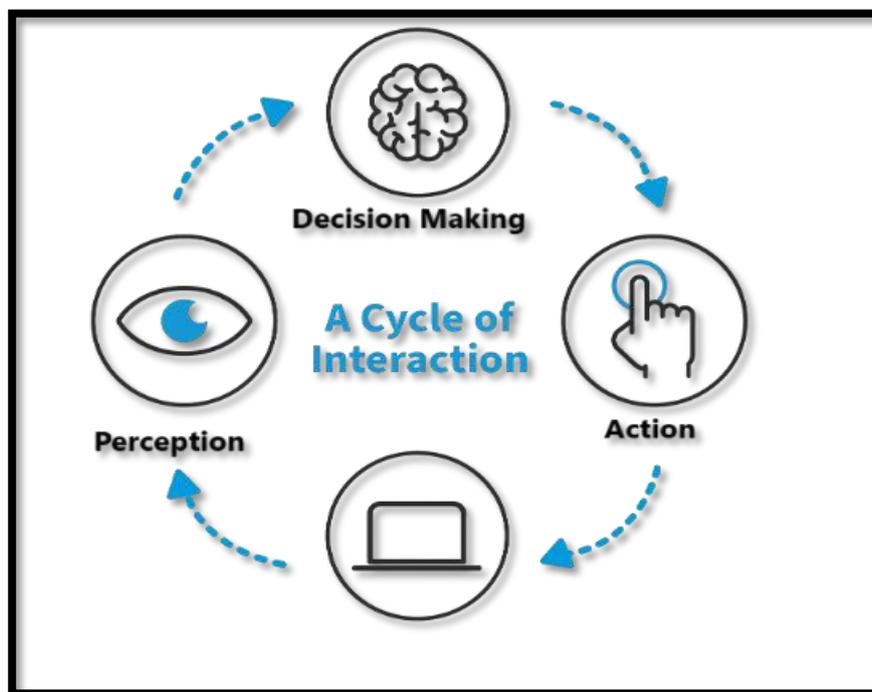
1. Perception (Sensing)

This is the first step where the robot **gathers information** from its surroundings. It uses **sensors** to detect objects, light, temperature, sound, or even touch. Sensors help the robot "see," "hear," or "feel" the environment just like humans use their eyes, ears, and skin. For example, a **robotic vacuum cleaner** has special sensors to detect **dirt, walls, and furniture** so it knows where to clean and how to avoid obstacles.

2. Decision Making (Processing)

After collecting data, the robot's **brain (processor or microcontroller)** analyses the information and decides what to do next. Some robots follow **pre-programmed instructions**, while others use **Artificial Intelligence (AI)** to make smart decisions. For example, the robotic vacuum cleaner **processes the sensor data** and decides:

- Where to move next
- Whether it needs to clean a dirty spot more

- How to avoid obstacles like chairs or walls

3. Action (Movement)

Once the decision is made, the robot performs the required action using **motors, wheels, arms, or legs**. In the case of the **robotic vacuum cleaner**, it **moves around the room**, turns when it detects obstacles, and continues cleaning until the job is done.

Types of Robots

Robots come in different shapes and sizes, depending on what they are made for. Here are some common types:

1. Industrial Robot

Industrial robots are machines used in factories to help with tasks like building, welding, painting, and packing products. These robots work faster, more accurately, and for longer hours than humans. They are mostly used in industries like car manufacturing, electronics, food processing, and metalwork. Since robots do not get tired, they help companies produce more products in less time and at a lower cost.

Industrial robots have different parts that help them work properly. Robotic arms pick up and move objects, while sensors help the robot detect and measure things. Motors and actuators allow movement, and a control system (computer or software) gives instructions. Some industrial robots work independently, while others work with humans to make jobs easier.

One common example of industrial robots is in car factories, where they weld metal, assemble car parts, and paint vehicles with great precision. In electronics factories, robots help place tiny parts on circuit boards to make mobile phones and computers. The food industry also uses robots to cut, sort, and pack food items quickly.

Industrial robots have many benefits. They can work non-stop without breaks, making production much faster. They reduce mistakes, so products are of higher quality. They also make factories safer by doing dangerous jobs, like working with hot metals or chemicals, where humans might get hurt. Even though industrial robots can be expensive to set up, they save money over time by improving efficiency and reducing the need for human labour.

2. Service Robots

Service robots are machines that help people with everyday tasks. Unlike industrial robots that work in factories, service robots are used in homes, offices, hospitals, hotels, and public places**.** They perform different jobs such as cleaning, delivering items, providing security, and helping in healthcare**.** These robots make life easier by reducing human effort, saving time, and improving efficiency.

Service robots work using different technologies. They have sensors to detect objects, people, or obstacles. Motors and wheels help them move, and a control system, such as software or AI, allows them to follow commands and make decisions. Some service robots work on their own, while others need human supervision.

There are many types of service robots, each designed for a specific job. Cleaning robots, like robotic vacuum cleaners, clean floors automatically, while window-cleaning robots help clean tall buildings. Delivery robots carry food, medicines, or parcels in hotels, hospitals, and shopping centres. Security robots monitor areas, detect intruders, and alert security teams. Medical robots assist doctors by carrying medical supplies, helping in surgeries, and taking care of elderly or disabled patients. Customer service robots are used in hotels, airports, and shopping malls to give information and guide people. Personal assistant robots, like Alexa or Siri, help users by setting reminders, playing music, and answering questions.

Service robots offer many benefits. They save time and effort by handling tasks automatically, so people can focus on other activities. They can work in places that may be difficult or dangerous for humans, such as cleaning high-rise buildings or assisting in medical emergencies. Security robots improve safety by monitoring areas and detecting threats. Some service robots also help elderly and disabled individuals by providing assistance in daily tasks.

3. Medical Robot

Medical robots are machines that help doctors, nurses, and healthcare workers in hospitals and clinics. They perform different tasks such as assisting in surgeries, delivering medicines, helping patients recover, and disinfecting hospital rooms. These robots make medical procedures more precise, reduce human effort, and improve patient care.

One important type of medical robot is the surgical robot. These robots assist doctors in performing delicate surgeries with high accuracy. The surgeon controls the robot's arms, allowing for smaller cuts, less pain, and faster recovery for patients. Rehabilitation robots help patients regain movement after injuries or surgeries by guiding them through exercises. Tele-presence robots let doctors consult and check on patients from a distance, which is useful in remote areas with limited medical facilities. Medication dispensing robots ensure that the right medicines are given to the right patients, reducing mistakes. Disinfection robots use ultraviolet (UV) light or special cleaning sprays to kill germs and keep hospitals safe.

Medical robots provide many benefits. They help doctors perform surgeries with greater accuracy and less risk, making recovery quicker for patients. They also reduce the workload of hospital staff by taking care of tasks like delivering supplies and assisting in patient rehabilitation. These robots improve hygiene and safety by minimizing human contact with germs, which helps prevent infections.

4. Military and Defence Robot

Military and defence robots are machines used to help soldiers in security, surveillance, and combat. These robots take on dangerous tasks, making military operations safer and more effective. They are used for spying (reconnaissance), removing bombs, rescuing people, and even helping in battles.

One important type is the surveillance robot, which has cameras and sensors to watch over areas and detect threats. These robots can go into dangerous places like war zones without putting soldiers at risk. Bomb disposal robots are also very useful because they safely remove or deactivate explosives, preventing harm to people. Unmanned ground vehicles (UGVs) and unmanned aerial vehicles (UAVs) or drones are used to transport supplies, collect information, and even carry out airstrikes. Some advanced military robots are designed to support soldiers in battle by carrying weapons and providing protection.

These robots have many benefits. They keep soldiers safe by handling risky tasks, help in rescue missions, and allow the military to work in dangerous areas without putting human lives in danger. They also make missions faster and more efficient.

5. Space Robot

Space robots are machines that help explore space, assist astronauts, and perform tasks in places where humans cannot easily survive. They are designed to handle extreme temperatures, low gravity, and high radiation. These robots help scientists study planets, repair satellites, and collect important space data.

One famous space robot is the Mars Rover. NASA has sent rovers like Curiosity, Perseverance, and Opportunity to Mars. These robots use cameras and sensors to take pictures, collect soil samples, and study the planet's surface. Another example is Robonaut, a humanoid robot that helps astronauts on the International Space Station (ISS). It can hold tools, flip switches, and work in zero gravity.

Other space robots include satellites and robotic arms. Satellites orbit Earth and other planets to help with communication, weather forecasting, and navigation. The Canadarm is a robotic arm used on space shuttles and the ISS to repair equipment and grab incoming spacecraft.

6. Underwater Robots

Underwater robots are machines that help explore and work in oceans, lakes, and rivers. They are designed to handle deep water pressure, cold temperatures, and dark environments where

humans cannot easily go. These robots are used for studying marine life, exploring shipwrecks, repairing underwater structures, and helping in rescue missions.

There are two main types of underwater robots. Remotely Operated Vehicles (ROVs) are controlled by humans using a remote system. They are connected to a ship by a cable and can dive deep to explore, repair pipelines, or study sea creatures. An example is the ROV Jason, which has helped scientists study underwater volcanoes. The second type is Autonomous Underwater Vehicles (AUVs), which work without human control. They are programmed to explore on their own and collect data. A well-known example is Boaty McBoatface, which helps in deep-sea research and climate studies.

These robots are important because they help scientists explore places that are too deep or dangerous for humans. They play a big role in ocean research, underwater construction, and disaster recovery, such as finding lost ships or detecting oil leaks. As technology improves, underwater robots will continue to help us learn more about the ocean and its mysteries.

7. Humanoid Robots

Humanoid robots are robots that look and act like humans. They usually have a head, arms, and legs, and they can walk, talk, and interact with people. These robots use sensors, cameras, and artificial intelligence (AI) to understand their surroundings and respond like humans.

Humanoid robots are used in many ways. In customer service, robots like Sophia and Pepper help people by answering questions and providing information in shopping malls, hotels, and airports. In healthcare, they assist elderly people, remind patients to take medicine, and provide companionship. In education, they help children learn in a fun and interactive way. Some humanoid robots are also used in space research, where they work alongside astronauts in challenging environments.

These robots are useful because they can work in places that may be dangerous for humans and help with tasks that require human-like interaction. As technology improves, humanoid robots are becoming smarter and more helpful in daily life. In the future, they may be used even more in homes, workplaces, and space missions.

8. Autonomous Vehicle Robots

Autonomous vehicle robots are vehicles that can move on their own without a human driver. They use sensors, cameras, GPS, and artificial intelligence (AI) to detect obstacles, follow routes,

and navigate safely. These robots include self-driving cars, drones, and robotic delivery vehicles.

Self-driving cars, like those made by Tesla and Waymo, can travel on roads without a driver. They use cameras and sensors to detect traffic, pedestrians, and road signs, helping them drive safely. Autonomous drones are used for delivering packages, monitoring farms, and capturing aerial images. Robotic delivery vehicles, like Amazon Scout, can transport small packages to customers without human help.

Autonomous vehicle robots are helpful because they can reduce accidents, improve transportation, and make deliveries faster. They are also useful in disaster areas, military missions, and other risky environments. As technology improves, these robots will become more common in daily life, making transportation and logistics easier.

Autonomous Robots

Autonomous robots are machines that can work on their own without human control. They use sensors, cameras, and artificial intelligence (AI) to understand their surroundings, make decisions, and complete tasks by themselves. These robots can move, detect objects, and react to changes in their environment without needing direct instructions. For example, robotic vacuum cleaners like Roomba can sense dirt, avoid obstacles, and clean floors automatically. Self-driving cars, such as those made by Tesla and Waymo, can see traffic signals, detect people, and drive safely on the road. Autonomous drones are used for delivering packages, taking aerial photos, and checking large areas like farms and forests.

These robots are very useful because they can work in places that are dangerous or difficult for humans, such as space, deep oceans, and disaster areas. For example, NASA's Mars rovers explore Mars and send information back to Earth. Autonomous robots also help in hospitals by assisting doctors in surgeries and delivering medicines.

Semi-Autonomous Robots

Semi-autonomous robots are machines that can do some tasks on their own but still need human control for important decisions. These robots use sensors and artificial intelligence (AI) to understand their surroundings and take actions, but a human can take over when needed.

For example, military drones can fly by themselves, avoid obstacles, and take pictures, but a human controls when and where they should go or if they need to take action. Surgical robots help doctors perform precise surgeries, but the doctor still controls the robot's movements. Self-parking cars can find a parking spot and park themselves, but the driver can take over if necessary. These robots are useful in many areas like medicine, military, transportation, and industries. They help save time, reduce human effort, and make work safer and more accurate, while still allowing humans to step in when needed.

Difference between Autonomous and Semi-Autonomous Robots

Feature	Autonomous Robots	Semi-Autonomous Robots
Control	Works completely on its own without human control.	Needs human assistance for some decisions.
Decision Making	Uses AI and sensors to make decisions independently.	Can make some decisions but requires human input for complex tasks.
Examples	Self-driving cars, robotic vacuum cleaners, Mars rovers.	Military drones, surgical robots, self-parking cars.
Human Involvement	No human intervention is needed after programming.	Humans can take control when required.
Usage	Used in space exploration, home automation, and industries.	Used in military, medical surgeries, and transportation.
Flexibility	Works in unpredictable environments by itself.	Works independently but may need guidance in difficult situations.

The Role of Sensors and AI in Autonomous and Semi-Autonomous Robots

Sensors and Artificial Intelligence (AI) are essential components in both autonomous and semi-autonomous robots. They help robots perceive their environment, process information, and make decisions. While autonomous robots operate without human intervention, semi-autonomous robots require some level of human control but still use AI and sensors to function efficiently.

Role of Sensors in Robots

Sensors act as the "eyes, ears, and touch" of a robot. They collect information about the surroundings and help the robot understand the environment. There are different types of sensors used in autonomous and semi-autonomous robots, including:

1. Vision Sensors (Cameras and LiDAR)
- Robots use cameras to capture images and recognize objects, people, and obstacles.
- LiDAR (Light Detection and Ranging) helps robots measure distances and create a 3D map of the environment.

- Example: Self-driving cars use cameras and LiDAR to detect roads, traffic signals, and pedestrians.

2. Proximity and Distance Sensors (Ultrasonic, Infrared, and Radar)
- These sensors help robots detect nearby objects and avoid collisions.
- Example: Robotic vacuum cleaners use infrared sensors to detect walls and furniture while cleaning.

3. Motion and Orientation Sensors (Gyroscopes and Accelerometers)
- These sensors help robots maintain balance and understand movement.
- Example: Humanoid robots use gyroscopes to walk and stay upright.

4. Environmental Sensors (Temperature, Humidity, and Gas Sensors)
- These sensors measure environmental conditions, which is useful in industrial and space robots.
- Example: Underwater robots use temperature sensors to monitor ocean conditions.

Role of AI in Robots

AI acts as the "brain" of the robot. It processes sensor data, makes decisions, and helps robots perform tasks more efficiently. AI is especially important in autonomous and semi-autonomous robots because it allows them to learn, adapt, and work in different environments.

1. AI in Autonomous Robots
- AI enables robots to function without human control by recognizing patterns, learning from experiences, and making real-time decisions.
- Example: Drones use AI to navigate through different terrains and avoid obstacles while flying.

2. AI in Semi-Autonomous Robots
- AI assists humans by providing suggestions, automating certain tasks, and improving accuracy.
- Example: In robotic-assisted surgery, AI helps surgeons by enhancing precision and providing real-time feedback, but the surgeon still controls the procedure.

How Sensors and AI Work Together in Robots
- Sensors collect data from the environment.
- AI processes this data and decides the next action.
- The robot then performs the required task based on AI decisions.

For example, in an **autonomous delivery robot**:
1. Sensors detect obstacles, pedestrians, and traffic lights.
2. AI analyses this data to determine the safest and most efficient path.
3. The robot moves towards the destination while avoiding obstacles.

In a **semi-autonomous military robot**:
1. Sensors detect enemy movements and gather real-time battlefield data.
2. AI processes this information and provides recommendations.
3. A human operator makes the final decision before the robot takes action.
4.

Chapter Highlights

Robotics: The study and development of robots, integrating mechanical, electronic, and computational systems.

Key Components: Sensors, actuators, control systems, and power sources.

Functioning:
1. **Perception (Sensing)** – Collects data from the environment.
2. **Decision Making (Processing)** – Analyses data and makes decisions.
3. **Action (Movement)** – Performs tasks using motors and actuators.

Types of Robots:
- **Industrial** – Factory automation.
- **Service** – Household and customer service.
- **Medical** – Surgery and patient care.
- **Military & Defence** – Surveillance and combat.
- **Space** – Exploration beyond Earth.
- **Underwater** – Marine research and exploration.

Significance: Robots enhance efficiency, safety, and precision in various industries and everyday life.

Exercise

Multiple Choice Questions (MCQs)

1. What defines a robot as per modern understanding?
   a) A human-like machine
   b) A device that follows only manual commands
   c) A programmable machine that can sense, process, and act
   d) A machine that only performs mechanical work

2. Which of the following is NOT a type of robot?
   a) Humanoid
   b) Mobile
   c) Virtual
   d) Metaphysical

3. Isaac Asimov is known for:
   a) Inventing the first robot
   b) Defining the three laws of robotics
   c) Creating the first humanoid robot
   d) Developing robotic arms

4. Which of the following is an example of a real-world medical robot?
   a) Baxter
   b) Da Vinci Surgical System
   c) Atlas
   d) ASIMO
5. Which sector benefits the most from the use of industrial robots?
   a) Healthcare
   b) Manufacturing
   c) Agriculture
   d) Education
6. Robots in defence are primarily used for:
   a) Assisting soldiers in battle
   b) Autonomous combat and reconnaissance
   c) Playing war simulation games
   d) Managing inventory in military warehouses
7. What is the primary function of sensors in a robot?
   a) Processing data
   b) Providing power
   c) Gathering information from the environment
   d) Storing data
8. The term "cobot" refers to:
   a) A completely autonomous robot
   b) A collaborative robot working alongside humans
   c) A robotic system with artificial intelligence
   d) A robot designed for combat
9. Which field uses agricultural robots extensively?
   a) Space research
   b) Crop monitoring and harvesting
   c) Military defence
   d) Retail management
10. Which of the following is an ethical concern in robotics?
    a) The cost of manufacturing
    b) Energy consumption
    c) Job displacement
    d) The speed of processing

Fill in the Blanks
1. _____ robots are designed to resemble human appearance and behaviour.
2. The three laws of robotics were proposed by _____.
3. The use of robots in _____ helps perform surgeries with precision.
4. _____ is an example of a robot used in the entertainment industry.
5. Robots used in agriculture help in tasks such as _____ and irrigation.

True & False
1. Robots are only used in industrial applications.
2. Artificial Intelligence is necessary for all types of robots.
3. A humanoid robot is designed to mimic human actions.

4. Robots can work autonomously without any programming.
5. The use of robots in defence helps minimize human casualties.

Assertion-Reason Questions

Directions: In the following questions, two statements are given, one labelled as Assertion (A) and the other as Reason (R). Read both the statements and choose the correct option.

1. **Assertion (A):** Robots are widely used in the medical field for surgery.
   Reason (R): Robots can perform surgeries with greater precision than humans.
   a) Both A and R are true, and R is the correct explanation of A.
   b) Both A and R are true, but R is not the correct explanation of A.
   c) A is true, but R is false.
   d) A is false, but R is true.
2. **Assertion (A):** Industrial robots increase production efficiency.
   Reason (R): Robots can work continuously without fatigue.
   a) Both A and R are true, and R is the correct explanation of A.
   b) Both A and R are true, but R is not the correct explanation of A.
   c) A is true, but R is false.
   d) A is false, but R is true.
3. **Assertion (A):** Robots are replacing human workers in many industries.
   Reason (R): Robots require no maintenance or human supervision.
   a) Both A and R are true, and R is the correct explanation of A.
   b) Both A and R are true, but R is not the correct explanation of A.
   c) A is true, but R is false.
   d) A is false, but R is true.
4. **Assertion (A):** Robots can be programmed to make ethical decisions.
   Reason (R): Ethical decision-making requires human-like consciousness.
   a) Both A and R are true, and R is the correct explanation of A.
   b) Both A and R are true, but R is not the correct explanation of A.
   c) A is true, but R is false.
   d) A is false, but R is true.
5. **Assertion (A):** Robots in space exploration help reduce human risks.
   Reason (R): Robots can function in extreme environments where humans cannot survive.
   a) Both A and R are true, and R is the correct explanation of A.
   b) Both A and R are true, but R is not the correct explanation of A.
   c) A is true, but R is false.
   d) A is false, but R is true.

Short Answer Questions

1. Define a robot and its key components.
2. What are the different classifications of robots?
3. How do robots contribute to the healthcare sector?
4. Explain the significance of sensors in robotic systems.
5. What are the major ethical concerns in robotics?

Long Answer Questions

1. Explain the three laws of robotics given by Isaac Asimov and their relevance today.
2. Discuss the various applications of robots in different sectors such as medical, industrial, and defence.
3. How do collaborative robots (cobots) differ from traditional robots? Give examples.
4. Describe the role of artificial intelligence in modern robotics and its advantages.
5. Compare and contrast autonomous robots and manually operated robots with real-world examples.