CHAPTER 11
DIFFERENT COMPONENTS OF "ROBOT"

Learning Outcomes

- Frame in Robotics
- Types of Frame
- Types of Material
- Types of Wheel

Robots are made up of different parts that help them function properly. Some of the most important parts include the **frame, materials, and wheels**, which decide how strong, durable, and mobile the robot will be. The **frame** is like the skeleton of a robot, giving it shape and support. It can be made from different materials like **MDF (Medium Density Fibreboard), acrylic, aluminium, or steel**. MDF and acrylic are lightweight and good for small robots, while aluminium and steel are stronger and used for heavy-duty robots.

Wheels help robots move. There are different types of wheels for different movements. **Standard wheels** allow simple forward and backward motion, while **castor wheels** provide extra support. More advanced wheels like **Mecanum and Omni wheels** let the robot move in multiple directions without turning. Choosing the right frame, material, and wheels is important in building robots for different tasks, whether it's for factories, research, or learning. This chapter will explain how these parts work and why they matter in robot design.

Examining Frames in Robotics

The **frame** of a robot is its structural backbone, providing support, stability, and shape. It holds all the essential components together, including motors, sensors, controllers, and actuators. The choice of frame design depends on the type of robot, its function, and the environment in which it operates. A well-designed frame ensures durability, proper weight distribution, and efficient movement.

Types of Frames

Fixed Frames:

- These frames are rigid and do not move or change shape.
- Common in **industrial robots** and **robotic arms** where stability is needed.

Modular Frames:

- Made up of multiple parts that can be rearranged or modified.

- Useful for **customizable robots**, allowing easy upgrades and repairs.

Flexible Frames:

- Designed to bend or adjust to external forces.
- Used in **soft robotics** for applications that requires delicate handling, such as medical robots.

Factors Affecting Frame Selection

Material Choice: Frames can be made from **MDF (Medium Density Fibreboard), acrylic, aluminium, or steel**, each having different properties:

- **MDF**: Lightweight and easy to cut, suitable for small robots.
- **Acrylic**: Strong and transparent but can be brittle.
- **Aluminium**: Lightweight, strong, and corrosion-resistant, ideal for most robotic applications.
- **Steel**: Very strong but heavy, used for heavy-duty robots.

Weight Considerations:

- A **lighter frame** helps in reducing power consumption and increasing speed.
- A **heavier frame** provides stability but may require stronger motors.

Size and Shape:

- The size of the frame should match the robot's purpose.
- For example, **small compact robots** need a minimal frame, while **large industrial robots** need strong, reinforced frames.

Mounting and Compatibility:

- The frame should have proper mounting points for wheels, motors, sensors, and other components.
- It should also be compatible with different modules for easy expansion.

Importance of Frames in Robotics

A well-built frame ensures that the robot performs its tasks efficiently and remains durable in different working conditions. Whether in **autonomous vehicles, robotic arms, or humanoid robots**, selecting the right frame structure is a key step in designing a functional and reliable robot.

Materials Used in Robot Frames

Choosing the right material for a robot's frame is very important because it affects how strong, light, and long-lasting the robot will be. Different materials have different properties, so the choice depends on what the robot needs to do. The most commonly used materials for building robot frames are **MDF (Medium Density Fibreboard), acrylic, aluminium, and steel**. Each material has its own advantages and disadvantages, and selecting the right one is important for building a good robot.

MDF (Medium Density Fibreboard)

MDF is a type of wood that is made by pressing wood fibres together with glue. It is lightweight, easy to cut, and not very expensive, making it a good choice for beginners and prototype robots. MDF has a smooth surface, so it can be painted or decorated easily.

However, it is not very strong and can break if too much weight is put on it. It also absorbs water, which can make it swell and weaken over time. Another issue is that cutting MDF produces fine dust, which can be harmful if breathed in. Because it is cheap and easy to work with, MDF is mostly used for making small robots and test models.

Acrylic

Acrylic is a type of plastic that is clear and lightweight. It is often used in robots for making covers and decorative parts. One big advantage of acrylic is that it does not rust, so it stays in good condition for a long time. However, acrylic is fragile and can break if dropped or hit too hard. It also scratches easily, which can make it look dull over time. Drilling holes in acrylic must be done carefully, or else it might crack. Because of its lightweight and attractive appearance, acrylic is mostly used for robot casings, panels, and display parts.

Aluminium

Aluminium is a strong but lightweight metal that is commonly used in robotics. It does not rust, which makes it a long-lasting material. Aluminium is easy to cut, shape, and drill, making it flexible for different robot designs. It also helps to cool down motors and electronic parts because it conducts heat well. However, aluminium is more expensive than MDF or acrylic. Although it is strong, it is not as tough as steel and can bend under extreme pressure. Due to its strength and light weight, aluminium is widely used in robotic arms, drones, and moving robots.

Steel

Steel is the strongest and heaviest material used in robotics. It is extremely durable and can handle heavy loads and tough working conditions. Steel does not break or bend easily, making it a good choice for robots that need to be very strong. It can also be welded, which helps in making strong joints in robotic frames. However, steel is very heavy, which means that the robot will need more powerful motors to move. It is also more expensive than other materials and can rust if it is not properly coated or treated. Because of its strength, steel is mostly used in industrial robots, robotic arms, and heavy-duty machines that need to lift heavy objects.

Choosing the Right Material

The best material for a robot's frame depends on its purpose, budget, and required strength. MDF and acrylic are good for small robots and prototypes because they are cheap and easy to

work with. Aluminium is a great choice for robots that need to be strong but still lightweight, such as drones and robotic arms. Steel is the best option for robots that need extra strength and durability, like industrial and heavy-duty robots. Understanding the advantages and disadvantages of each material helps in choosing the best one for building a successful robot.

Different Types of Wheels Used in Robots

Wheels help robots move, and the type of wheel used affects how smoothly and easily a robot can travel. Some wheels are simple and move only forward and backward, while others allow movement in any direction. Choosing the right wheel depends on what the robot needs to do. The four most common types of wheels used in robots are **standard wheels, castor wheels, Mecanum wheels, and Omni wheels**.

Standard Wheels

Standard wheels are the most common type, similar to the ones found in bicycles or cars. These wheels move forward and backward but cannot move sideways. To turn, one wheel moves faster than the other, which helps change direction.

These wheels are good for robots that need to follow a straight path or turn at angles. They offer good grip and work well on smooth and rough surfaces. However, they are not very flexible since they cannot move sideways. They are mostly used in **robotic cars, delivery robots, and basic wheeled robots**.

Castor Wheels

Castor wheels are small wheels that **rotate in all directions**. You might have seen them on office chairs and shopping carts. These wheels do not drive the robot forward but help it stay balanced and move smoothly.

Robots that use standard wheels often add one or more castor wheels to improve stability. They make turning easier and reduce friction. However, they do not help in movement and can sometimes slow the robot down slightly when changing direction. Castor wheels are commonly used in **robot vacuum cleaners, mobile robots, and industrial carts**.

Mecanum Wheels

Mecanum wheels are special wheels that **allow a robot to move in any direction without turning**. These wheels have small rollers placed at an angle, which lets the robot move forward, backward, sideways, and even diagonally.

To use Mecanum wheels, a robot must have **four wheels, each controlled by a separate motor**. By adjusting how each wheel moves, the robot can slide in any direction without rotating its body. This special movement is called **holonomic movement**,

which is very useful in **warehouse robots, industrial robots, and robots used in tight spaces**.

However, Mecanum wheels require **advanced programming** to control their movement properly, which makes them more complex than standard wheels.

Omni Wheels

Omni wheels work like Mecanum wheels but have rollers placed at **90-degree angles** around the main wheel. This design allows the robot to move in all directions, including sideways, without needing to turn.

Omni wheels are often used in **three-wheel or four-wheel robots** that need quick and smooth movement. They are popular in **robotic competitions, warehouse robots, and advanced mobile robots**.

While Omni wheels offer great flexibility, they have **fewer grips on the ground** compared to standard wheels. This makes them less suitable for outdoor or rough surfaces.

Choosing the Right Wheel

The best wheel for a robot depends on how it needs to move:

- **Standard wheels** are best for simple robots that move in straight lines.
- **Castor wheels** help with balance and smooth movement.
- **Mecanum wheels** allow movement in all directions, making them ideal for industrial robots.
- **Omni wheels** are great for fast, smooth movement in any direction.

Chapter Highlights

- **Robot frame** acts as the skeleton, holding all components and providing structure.
- **Fixed frames** are rigid and stable; used in robotic arms and industrial robots.
- **Modular frames** can be reconfigured for customization and easy repairs.
- **Flexible frames** bend and adapt; used in soft robotics like medical devices.
- **Common frame materials** include MDF, acrylic, aluminium, and steel.
- **MDF** is cheap and light but weak and water-sensitive.
- **Acrylic** is rust-free and attractive but brittle and scratch-prone.
- **Aluminium** is lightweight, strong, and rust-resistant; ideal for most robots.
- **Steel** is very strong and durable but heavy; used for heavy-duty machines.
- **Wheels** decide robot movement – standard (forward/back), castor (support), Mecanum & Omni (multi-directional).
- **Mecanum wheels** allow holonomic (all-direction) movement using angled rollers.
- Choosing the **right frame, material, and wheels** ensures stability, mobility, and task efficiency.

Exercise

Multiple-Choice Questions (MCQs)

1. What is the main function of a robot's frame?
   a) To power the motors
   b) To display output
   c) To provide structure and support
   d) To store data
2. Which of the following materials is best suited for a lightweight beginner robot?
   a) Steel
   b) Aluminium
   c) MDF
   d) Acrylic
3. Which wheel type allows sideways movement without turning?
   a) Standard wheel
   b) Castor wheel
   c) Omni wheel
   d) Fixed wheel
4. What is the main disadvantage of acrylic material?
   a) It is very heavy
   b) It absorbs water
   c) It breaks easily
   d) It is hard to cut
5. Which material is the **strongest but heaviest** for robot frames?
   a) MDF
   b) Acrylic
   c) Aluminium
   d) Steel
6. Which wheel type is commonly found on office chairs?
   a) Mecanum wheel
   b) Omni wheel
   c) Castor wheel
   d) Standard wheel
7. Which type of frame can be easily rearranged or upgraded?
   a) Fixed
   b) Modular
   c) Flexible
   d) Circular
8. Mecanum wheels require:
   a) One motor
   b) A pair of servo motors
   c) Four independently driven motors
   d) Manual control
9. Which material offers rust resistance and is commonly used in robot arms?
   a) Steel
   b) MDF

c) Aluminium
d) Plastic

10. What is a key use of Omni wheels?
    a) Rough terrain movement
    b) Long-distance travel
    c) Smooth multi-directional motion
    d) Jumping movement

True or False

1. MDF is suitable for water-based environments.
2. Modular frames allow easy customization of robots.
3. Steel is lightweight and ideal for small robots.
4. Castor wheels help in balancing and smooth turns.
5. Omni wheels have rollers placed at 45-degree angles.

Fill in the Blanks

1. The _____ of a robot provides structure and support.
2. _____ is a clear plastic material used for decorative robot parts.
3. _____ wheels rotate in all directions and are used for smooth turning.
4. _____ is the strongest material used in heavy-duty robots.
5. Mecanum wheels enable _____ movement.

Assertion and Reason

1. **Assertion (A):** Aluminium is commonly used in robot frames.
   Reason (R): Aluminium is strong, lightweight, and corrosion-resistant.
   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):** MDF is ideal for heavy industrial robots.
   Reason (R): MDF is lightweight and absorbs moisture.
   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):** Mecanum wheels enable robots to move sideways without turning.
   Reason (R): Mecanum wheels have rollers set at specific angles for multidirectional movement.
   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):** Steel is the lightest material used in robot frames.
   Reason (R): Steel is used for building compact, lightweight mobile robots.
   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, and R is false.

5. **Assertion (A):** Castor wheels assist with turning and stability.
   Reason (R): Castor wheels can rotate in all directions but are not driven by motors.
   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. What is the role of a robot's frame?
2. Name any two materials used for robot frames and one advantage of each.
3. What is the difference between Mecanum and Omni wheels?
4. Why is aluminium a popular choice for building robot frames?
5. Mention one use of castor wheels in mobile robots.

Long Answer Questions

1. Explain the advantages and disadvantages of MDF, acrylic, aluminium, and steel as frame materials.
2. Describe different types of frames used in robots with examples.
3. Compare the functions and uses of standard, castor, Mecanum, and Omni wheels.
4. How do Mecanum wheels provide holonomic motion? Describe with working.
5. Why is selecting the right combination of frame, material, and wheel important in robot design?