Independent Skill Development Mission

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📖 UNDERSTANDING SENSORS: ULTRASONIC, INFRARED, TOUCH, & LIGHT SENSORS

CHAPTER 1: INTRODUCTION TO SENSORS IN ROBOTICS

1.1 What are Sensors?

A **sensor** is a device that detects and measures changes in the environment, such as distance, light, temperature, or physical touch, and sends this information to a robot's microcontroller. Sensors help robots **interact with the world** and make decisions based on real-time data.

1.2 Why are Sensors Important in Robotics?

1. **Enable Autonomy** – Robots can detect surroundings and respond without human input.
2. **Improve Accuracy** – Sensors provide precise measurements for navigation and control.
3. **Enhance Safety** – Robots can avoid obstacles and prevent collisions.

4. **Enable Interaction** – Robots can respond to human touch and environmental changes.

1.3 Types of Sensors Used in Robotics

- **Ultrasonic Sensor** – Measures distance using sound waves.
- **Infrared (IR) Sensor** – Detects objects and measures heat.
- **Touch Sensor** – Detects physical contact and pressure.
- **Light Sensor** – Measures the intensity of light in the environment.

CHAPTER 2: ULTRASONIC SENSORS

2.1 What is an Ultrasonic Sensor?

An **ultrasonic sensor** measures distance by sending out high-frequency sound waves and detecting how long they take to bounce back after hitting an object.

2.2 How Does an Ultrasonic Sensor Work?

1. The **sensor emits sound waves** at a frequency higher than humans can hear.
2. The sound waves **hit an object** and reflect back.
3. The **sensor calculates the distance** based on the time taken for the sound to return.

Formula for Distance Calculation:

Distance = (Speed of Sound × Time Taken) ÷ 2

Example: If the sound wave takes 0.02 seconds to return, the distance = **(343 m/s × 0.02) ÷ 2 = 3.43 meters**.

2.3 Uses of Ultrasonic Sensors in Robotics

1. **Obstacle detection** – Helps robots avoid collisions.
2. **Autonomous navigation** – Used in self-driving cars and drones.
3. **Proximity sensing** – Used in automated doors and parking sensors.

Example Application: In LEGO Mindstorms robots, the **Ultrasonic Sensor** helps the robot detect walls and stop before hitting them.

CHAPTER 3: INFRARED (IR) SENSORS

3.1 What is an Infrared Sensor?

An **infrared (IR) sensor** detects infrared radiation (heat) or objects by measuring how much IR light is reflected or absorbed.

3.2 How Does an IR Sensor Work?

1. **Active IR Sensors** emit infrared light and measure the reflection.
2. **Passive IR Sensors (PIR)** detect heat emitted by objects (e.g., humans, animals).

Types of IR Sensors:

- **Proximity Sensors** – Detect objects by measuring reflected infrared light.

- **Line Following Sensors** – Used in line-following robots to track a black or white line.
- **Motion Sensors (PIR Sensors)** – Detects movement using heat detection.

3.3 Uses of IR Sensors in Robotics

1. **Line-following robots** – Used in autonomous vehicles and industrial robots.
2. **Remote controls** – Used in TVs and air conditioners.
3. **Security systems** – Used in motion detectors for alarm systems.

Example Application: A **line-following robot** uses IR sensors to stay on a track by detecting the difference between **light and dark surfaces**.

CHAPTER 4: TOUCH SENSORS

4.1 What is a Touch Sensor?

A **touch sensor** detects physical contact, such as pressing or tapping, and sends signals to a microcontroller.

4.2 How Does a Touch Sensor Work?

1. Some sensors detect **direct pressure** (mechanical switches).
2. Some use **capacitive sensing**, like smartphone touchscreens.

Types of Touch Sensors:

- **Mechanical Switch Sensors** – Used in buttons and keypads.

- **Capacitive Touch Sensors** – Detect the electrical properties of human touch.

4.3 Uses of Touch Sensors in Robotics

1. **Collision detection** – Robots stop when they hit an object.
2. **Human interaction** – Used in robotic assistants and toys.
3. **Smartphones & touchscreens** – Used in everyday touch technology.

Example Application: In LEGO Mindstorms, a **Touch Sensor** can be programmed to **stop the robot when it collides with an object**.

CHAPTER 5: LIGHT SENSORS

5.1 What is a Light Sensor?

A **light sensor** measures the brightness of the surrounding environment and helps robots respond to changes in light intensity.

5.2 How Does a Light Sensor Work?

1. Converts **light energy** into an **electrical signal**.
2. Can detect **brightness levels** or **color variations**.

Types of Light Sensors:

- **Photodiodes** – Detect brightness levels.
- **Color Sensors** – Detect colors and contrast.

5.3 Uses of Light Sensors in Robotics

1. **Line-following robots** – Used to detect contrast between black and white surfaces.

2. **Solar-powered robots** – Adjust movement based on sunlight levels.
3. **Ambient light sensing** – Used in smartphones to adjust screen brightness.

Example Application: A **solar-powered robot** uses a light sensor to adjust its position for maximum energy absorption from the sun.

CHAPTER 6: COMPARING DIFFERENT SENSORS

Feature	**Ultrasonic Sensor**	**Infrared Sensor**	**Touch Sensor**	**Light Sensor**
Measures	Distance	Heat/Proximity	Physical Contact	Light Intensity
Detection Type	Sound Waves	Infrared Light	Pressure	Brightness
Common Use	Obstacle Avoidance	Line Following	Collision Detection	Ambient Light Control
Example	Self-driving Cars	Remote Controls	Robot Buttons	Solar Robots

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CHAPTER 7: EXERCISES & ASSIGNMENTS

7.1 Multiple Choice Questions

1. What does an **ultrasonic sensor** measure?

- (a) Temperature
- (b) Distance ✅
- (c) Light
- (d) Pressure

2. Which sensor is used in **motion detectors**?
   - (a) Touch sensor
   - (b) Light sensor
   - (c) PIR infrared sensor ✅
   - (d) Ultrasonic sensor
3. What is the function of a **touch sensor**?
   - (a) Detects pressure and physical contact ✅
   - (b) Measures temperature
   - (c) Calculates speed
   - (d) Detects sound waves
4. Which sensor is best for a **line-following robot**?
   - (a) Ultrasonic Sensor
   - (b) Infrared Sensor ✅
   - (c) Touch Sensor
   - (d) Light Sensor

7.2 Practical Assignments

1. Draw and label a **diagram of a robot using different sensors**.
2. Research and write about **a real-world robot that uses multiple sensors** (e.g., a self-driving car or robotic vacuum).
3. Design a **simple robot program** using a LEGO Mindstorms touch sensor to stop when it hits an obstacle.

CHAPTER 8: SUMMARY

1. **Sensors help robots interact with their environment** by detecting objects, movement, touch, and light.
2. **Ultrasonic sensors** measure distance using sound waves.
3. **Infrared sensors** detect heat and proximity.
4. **Touch sensors** respond to physical contact.
5. **Light sensors** measure brightness and color changes.

📖 How Robots Use Sensors to Detect Obstacles

📌 Chapter 1: Introduction to Sensors in Robotics

What are Sensors?

A **sensor** is a device that allows a robot to detect and respond to changes in its environment. Sensors help robots gather information, process it, and make decisions based on real-world conditions.

📌 **Definition:**
"A sensor is an electronic component that detects physical changes in the environment and sends data to the robot's microcontroller for processing."

Why Do Robots Need Sensors?

✓ **Obstacle Detection** – Helps robots avoid collisions.
✓ **Navigation** – Enables autonomous movement.
✓ **Automation** – Allows robots to operate without human control.
✓ **Safety** – Prevents damage to robots and their surroundings.

📌 **Example:**
A **self-driving car** uses multiple sensors to detect nearby vehicles and pedestrians to avoid accidents.

📌 Chapter 2: Types of Sensors Used for Obstacle Detection

Robots use different types of sensors to detect and avoid obstacles. Below are the most common ones:

Ultrasonic Sensors (Sound-Based Detection)

✓ Uses **high-frequency sound waves** (similar to echolocation in bats).
✓ Measures the **time taken** for sound waves to hit an obstacle and return.
✓ Provides accurate distance measurement.

📌 **Example Usage:**
🔹 Used in **autonomous robots** and **self-driving cars** to detect nearby objects.

Code Example (Using Python & Arduino):

```
distance = ultrasonic_sensor.get_distance()

if distance < 10:  # If an object is detected within 10 cm
   stop_robot()
else:
   move_forward()
```

✓ **Effect:** The robot stops if an object is detected within 10 cm.

Infrared Sensors (Light-Based Detection)

✓ Emits **infrared light** and detects reflection from nearby objects.
✓ Works well in **short-range obstacle detection**.
✓ Less effective in bright sunlight due to interference.

📌 **Example Usage:**

🔹 Used in **automatic doors** and **line-following robots**.

Code Example:

```
if infrared_sensor.detects_obstacle():
  turn_left()
else:
  move_forward()
```

✓ **Effect:** The robot turns left when an obstacle is detected.

LIDAR Sensors (Laser-Based Detection)

✓ Uses **laser beams** to create a 3D map of the environment.
✓ Provides **high-precision** obstacle detection.
✓ Used in **advanced robotics and self-driving vehicles**.

📌 **Example Usage:**

🔹 Used in **self-driving cars (Tesla, Waymo)** and **robotic vacuum cleaners**.

Code Example:

```
if lidar.detects_object():
  slow_down()
```

✓ **Effect:** The robot slows down when an object is detected.

Touch Sensors (Physical Contact Detection)

✓ Detects an obstacle **when the robot makes physical contact**.

✓ Works like a **button or switch** that is pressed when an object is hit.

📌 **Example Usage:**

- Used in **bumper robots** and **collision detection systems**.

Code Example:

```
if touch_sensor.is_pressed():
    move_backward()
```

✓ **Effect:** The robot moves backward when it touches an object.

📌 Chapter 3: How Sensors Work Together in Robots

Combining Multiple Sensors for Accuracy

Most robots **use multiple sensors together** for better obstacle detection.

📌 **Example: Self-Driving Car**

- **Ultrasonic Sensors** – Detect nearby objects.
- **LIDAR Sensors** – Create a 3D map of the road.
- **Infrared Sensors** – Detect lane markings and signals.
- **Cameras & AI** – Recognize pedestrians and traffic lights.

Example: Smart Obstacle-Avoidance Robot

A robot can combine **ultrasonic and infrared sensors** for better navigation:

```
while True:
```

```
if ultrasonic_sensor.get_distance() < 10 or infrared_sensor.detects_obstacle():
    turn_right()
else:
    move_forward()
```

✓ **Effect:** The robot moves forward unless an obstacle is detected, then it turns right.

📌 Chapter 4: Exercises & Assignments

Multiple Choice Questions

What sensor is best for long-range obstacle detection?

- (a) Touch Sensor
- (b) Infrared Sensor
- (c) LIDAR Sensor ✅
- (d) None of the above

How does an ultrasonic sensor detect obstacles?

- (a) Using a camera
- (b) By sending sound waves and measuring their reflection ✅
- (c) By detecting heat
- (d) By physical contact

What type of sensor is commonly used in line-following robots?

- (a) Infrared Sensor ✅
- (b) Ultrasonic Sensor
- (c) Touch Sensor
- (d) GPS Sensor

Which sensor works like a button and detects obstacles when touched?

- (a) LIDAR Sensor
- (b) Infrared Sensor
- (c) Ultrasonic Sensor
- (d) Touch Sensor ✅

Practical Assignments

📌 **Task 1:** Draw and label a **robot with sensors** for obstacle detection.

📌 **Task 2:** Write a **step-by-step algorithm** for a robot that moves forward until it detects an obstacle.

📌 **Task 3:** Modify the following code so that the robot **turns left** instead of stopping when an obstacle is detected:

```
if ultrasonic_sensor.get_distance() < 10:
    stop()
```

📌 Chapter 5: Summary

✅ **Sensors allow robots to detect and respond to obstacles** in their environment.

✅ **Ultrasonic sensors** use sound waves, **infrared sensors** use light, and **LIDAR sensors** use lasers.

✅ **Touch sensors** detect physical contact, while **LIDAR sensors** help create a **3D map** of surroundings.

✅ **Most robots use multiple sensors together** for accuracy and reliability.

📖 Automation & Real-World Applications of Sensor-Based Robotics

📌 Chapter 1: Introduction to Automation in Robotics

1.1 What is Automation?

Automation is the use of **technology, machines, and AI** to perform tasks **without human intervention**. In robotics, automation allows robots to work independently, improving efficiency and reducing human workload.

Examples of Automation in Daily Life:

- Self-checkout machines in supermarkets
- Automatic streetlights that turn on at night
- Smart home assistants like Alexa and Google Home
- Industrial robots assembling cars in factories

1.2 Role of Sensors in Automation

- Sensors collect **real-time data** from the environment.
- The **robot's microcontroller (brain)** processes the data.
- The robot takes actions based on the **sensor readings**.

Example: In self-driving cars, sensors **detect traffic lights**, and the car **stops automatically** when the light turns red.

📌 Chapter 2: Types of Sensors Used in Automation

2.1 Commonly Used Sensors in Automated Robots

Sensor Type	Function	Example Use
Ultrasonic Sensor	Measures distance using sound waves	Obstacle avoidance in self-driving cars
Infrared (IR) Sensor	Detects objects and heat	Line-following robots
Touch Sensor	Senses physical contact	Bumper sensors in cleaning robots
Light Sensor	Detects brightness levels	Automatic streetlights
Motion Sensor	Detects movement	Security systems and automatic doors
Temperature Sensor	Measures heat	Industrial automation and weather monitoring

Example: In smart air conditioners, **temperature sensors** detect room temperature and adjust cooling automatically.

📌 Chapter 3: Real-World Applications of Sensor-Based Robotics

3.1 Industrial Automation

- **Manufacturing Robots** – Assemble cars, mobile phones, and electronics with high precision.

- **AI-Powered Quality Control** – Use cameras and sensors to detect defects in products.
- **Warehouse Automation** – Robots like **Amazon's Kiva Robots** sort and transport products in warehouses.

Example: Tesla's car factories use robotic arms with **touch and vision sensors** to assemble vehicles.

3.2 Healthcare & Medical Robotics

- **Surgical Robots (e.g., Da Vinci Robot)** – Assist doctors in complex surgeries with high precision.
- **Prosthetic Limbs** – Use **touch sensors** to detect movement and pressure.
- **Medical Delivery Robots** – Transport medicines and supplies in hospitals.

Example: Robots in hospitals can **deliver food and medicine** to patients, reducing human contact during pandemics.

3.3 Smart Homes & IoT (Internet of Things) Automation

- **Smart Lights & Doors** – Use **light and motion sensors** to turn on/off.
- **AI-Powered Assistants** – Robots like Alexa and Google Home use voice recognition sensors.
- **Automated Vacuum Cleaners (e.g., Roomba)** – Use **ultrasonic and touch sensors** to navigate rooms.

Example: A smart doorbell camera **detects movement** and sends alerts to homeowners.

3.4 Agriculture & Farming Automation

- **Smart Irrigation Systems** – Use **moisture sensors** to water crops only when needed.
- **Drones for Crop Monitoring** – Use **infrared and vision sensors** to monitor plant health.
- **Automated Harvesting Machines** – Use **robotic arms and AI** to pick ripe fruits.

Example: John Deere's **autonomous tractors** use GPS and sensors to plow fields without human drivers.

3.5 Self-Driving Vehicles & Delivery Robots

- **Autonomous Cars (e.g., Tesla, Waymo)** – Use **LIDAR, ultrasonic, and vision sensors** to detect traffic and pedestrians.
- **Delivery Robots (e.g., Starship Robots)** – Use **GPS and cameras** to navigate and deliver food and packages.

Example: Self-driving taxis in cities like San Francisco use AI and sensors to transport passengers safely.

3.6 Space Exploration & Defense Robots

- **NASA's Mars Rovers (Curiosity, Perseverance)** – Use **ultrasonic and vision sensors** to explore Mars.
- **Military Drones** – Use **thermal and motion sensors** for surveillance.
- **Underwater Exploration Robots** – Detect objects using **sonar sensors**.

Example: NASA's **Perseverance Rover** is exploring Mars and collecting data for future space missions.

📌 Chapter 4: Future Trends in Sensor-Based Robotics

- **AI and Machine Learning in Robots** – Robots will **learn from experience** and improve decision-making.
- **5G & IoT Integration** – Faster communication between robots and cloud servers.
- **Humanoid Robots** – AI-powered robots like **Tesla Bot** will assist humans in daily tasks.
- **Autonomous Delivery Drones** – Companies like Amazon and Google are testing **AI-powered drone delivery**.

Example: Future robots may act as **personal assistants,** helping elderly people with daily tasks.

📌 Chapter 5: Exercises & Assignments

5.1 Multiple Choice Questions

1. What is automation in robotics?
   - (a) Robots controlled manually
   - (b) The use of robots to perform tasks automatically ✅
   - (c) A type of programming
   - (d) Robots that do not require electricity
2. Which sensor is used in **self-driving cars** for obstacle detection?
   - (a) Motion Sensor

- (b) Ultrasonic Sensor ✅
- (c) Touch Sensor
- (d) Temperature Sensor

3. What is an example of **medical automation**?
   - (a) Robotic arms in car manufacturing
   - (b) Automated cleaning robots
   - (c) Surgical robots assisting doctors ✅
   - (d) AI-powered home assistants
4. Which company manufactures self-driving **electric cars**?
   - (a) Ford
   - (b) Tesla ✅
   - (c) Microsoft
   - (d) Samsung

5.2 Practical Assignments

- **Task 1:** Research and write about **how Tesla's Autopilot uses sensors for self-driving**.
- **Task 2:** Draw a **flowchart** showing how **a smart irrigation system** works in agriculture.
- **Task 3: Design your own AI-powered home assistant robot** and describe what sensors it would use.

📌 CHAPTER 6: SUMMARY

- **Automation** allows robots to perform tasks without human intervention.
- **Sensors** collect environmental data, helping robots **navigate, detect objects, and make decisions**.
- **Self-driving cars, smart homes, and industrial robots** use sensor-based automation.
- **Healthcare, farming, and space exploration** benefit from robotics automation.
- The future of robotics will see **more AI-powered, self-learning machines**.

🕮 Programming a Robot to Respond to Environment Changes

📌 Chapter 1: Understanding Environmental Interaction in Robots

What Does it Mean for a Robot to Respond to Environment Changes?

Robots interact with their surroundings using **sensors** and **decision-making algorithms**. Environmental changes may include:

✓ **Obstacle Detection** – Detecting walls, objects, or people.
✓ **Light & Color Detection** – Responding to different lighting conditions.
✓ **Temperature Changes** – Adjusting functions based on heat.
✓ **Motion Detection** – Reacting to movement around it.
✓ **Sound & Voice Recognition** – Understanding and responding to sound inputs.

📌 **Example:** A **self-driving car** stops when a pedestrian is detected in front of it.

📌 Chapter 2: Sensors Used for Detecting Environmental Changes

What Are Sensors in Robotics?

Sensors allow robots to **perceive** and **understand** their surroundings. Robots use different types of sensors depending on the environmental input they need to process.

Types of Sensors Used in Robots

- **Ultrasonic Sensors:** Used for detecting obstacles and measuring distance.
- **Infrared (IR) Sensors:** Detect heat, objects, or motion.
- **Light Sensors:** Measure brightness levels.
- **Temperature Sensors:** Detect changes in temperature for heat management.
- **Touch Sensors:** Help robots sense physical contact or pressure.
- **Sound Sensors:** Detect voices and external sounds.

📌 **Example:** A **line-following robot** uses a **light sensor** to stay on a path.

📌 Chapter 3: How Robots Make Decisions Based on Sensors

Using Sensors to Process Data

- The **sensor** detects a change in the environment.
- The **robot's microcontroller** processes the sensor data.
- The robot makes a **decision** based on programmed conditions.
- The **robot performs an action** (moving, stopping, changing direction, etc.).

📌 **Example:** A smart home robot **turns on lights** when it detects a dark room.

Decision-Making Using Conditional Statements

✓ **If-Else Statements** – Help the robot decide what to do in different conditions.

📌 **Example:** A robot avoids obstacles using an **if-else condition:**

```
if obstacle_detected():
    stop()
else:
    move_forward()
```

✓ **Effect:** The robot stops if it detects an obstacle, otherwise it keeps moving.

📌 Chapter 4: Programming a Robot to Respond to Environment Changes

Writing Code for a Robot to Respond to Light Changes

📌 **Example: A Light-Sensitive Robot that Moves in Darkness**

```
if light_sensor_value < 50:  # Dark environment
    move_forward()
else:
    stop()
```

✓ **Effect:** The robot moves forward in the dark and stops in the light.

Programming a Robot to Avoid Obstacles

📌 Example: Using an Ultrasonic Sensor to Detect Obstacles

```
while True:
  if ultrasonic_sensor_distance() < 10:  # Object detected within 10 cm
    stop()
    turn_right()
  else:
    move_forward()
```

✓ **Effect:** The robot moves forward and **turns** when an obstacle is detected.

Programming a Robot to Follow a Line

📌 Example: A Line-Following Robot Using a Light Sensor

```
while True:
  if light_sensor() == "black":
    move_forward()
  else:
    turn_left()
```

✓ **Effect:** The robot **follows the black line** and turns when needed.

📌 Chapter 5: Exercises & Assignments

Multiple Choice Questions

What sensor is used to detect nearby objects?

- (a) Light sensor
- (b) Ultrasonic sensor ✅
- (c) Temperature sensor
- (d) Sound sensor

What happens when a robot detects an obstacle using an ultrasonic sensor?

- (a) It moves forward
- (b) It stops or changes direction ✅
- (c) It beeps but does not stop
- (d) Nothing happens

What kind of sensor allows robots to detect color differences?

- (a) Light sensor ✅
- (b) Ultrasonic sensor
- (c) Touch sensor
- (d) Temperature sensor

Which programming statement helps a robot decide what to do based on a condition?

- (a) Loop

- (b) Variable
- (c) If-Else ✅
- (d) Function

Practical Assignments

📌 **Task 1:** Write a simple program to make a robot **turn on an LED light in the dark**.
📌 **Task 2:** Design a **flowchart** showing how a robot avoids obstacles using an ultrasonic sensor.
📌 **Task 3:** Modify the following code to make the robot turn left instead of right when it detects an obstacle:

```
if ultrasonic_sensor_distance() < 10:
  stop()
  turn_right()
```

📌 Chapter 6: Summary

✅ Robots **use sensors** to respond to environmental changes.
✅ **Conditional statements** (if-else) allow robots to make decisions.
✅ **Loops** keep checking sensor inputs and repeat actions as needed.
✅ Robots can be programmed to **move in the dark, follow lines, or avoid obstacles**.

📌 ASSIGNMENT:

☑ DRAW A CONCEPT SKETCH OF A SELF-DRIVING CAR WITH SENSORS.

📌 Assignment Solution: Draw a Concept Sketch of a Self-Driving Car with Sensors

🎯 Objective:

This step-by-step guide will help you create a **concept sketch of a self-driving car** and label the key sensors used in autonomous navigation.

🛠️ Step 1: Understand the Components of a Self-Driving Car

A self-driving car uses various **sensors and AI technology** to navigate and avoid obstacles. Here are the key components you need to include in your sketch:

Main Components to Include in the Sketch:

1. **Lidar Sensor** – Detects objects and measures distance using laser beams.
2. **Radar Sensor** – Helps detect vehicles and objects in bad weather.
3. **Camera Sensors** – Captures road signs, traffic signals, and pedestrians.
4. **Ultrasonic Sensors** – Detects nearby objects for parking assistance.
5. **GPS System** – Guides the car to follow a predefined route.
6. **AI Computer System** – Processes data from sensors to control movement.

📌 Step 2: Gather Your Drawing Materials

To draw the concept sketch, you will need:

✓ **A pencil and eraser** (for rough sketching)

✓ **A ruler** (for straight lines)

✓ **Colored pencils or markers** (optional for highlighting sensors)

✓ **Graph paper or blank paper**

📌 Step 3: Draw the Outline of the Self-Driving Car

1. **Start by sketching the body of the car** using simple shapes (rectangles and curves).
2. **Draw the wheels** at the bottom, keeping the car symmetrical.
3. **Add headlights, windows, and a windshield** to make it look realistic.

🔹 **Tip:** Keep the design simple; focus on adding sensors and labels.

📌 Step 4: Add Sensors to the Car

Now, place the essential sensors in the correct locations on the car:

Front Sensors:

1. **Lidar Sensor (on the roof)** – Draw a small box with a circular scanner on top.
2. **Front Camera Sensor** – Draw a small rectangle near the windshield.

Side Sensors:

3. **Radar Sensors (front & back bumpers)** – Draw small circles near the edges.
4. **Ultrasonic Sensors (side of the car)** – Draw small dots along the side for parking assistance.

Rear Sensors:

5. **Rear Camera Sensor (back of the car)** – Draw a tiny rectangle above the license plate.
6. **Ultrasonic Sensors (back bumper)** – Draw small circles for detecting obstacles while reversing.

🔹 **Tip:** Use **different colors** to highlight each sensor type in the sketch.

📌 Step 5: Label the Sensors & Add Explanations

1. **Write the name of each sensor** next to it in the sketch.
2. **Draw arrows** pointing to each sensor from a labeled text box.
3. **Add a short note** explaining what each sensor does.

Example Labels:
✓ **Lidar Sensor:** Detects objects and creates a 3D map of the surroundings.
✓ **Radar Sensors:** Help detect cars and large obstacles, even in fog or rain.
✓ **Camera Sensors:** Recognize traffic signs, lanes, and pedestrians.
✓ **Ultrasonic Sensors:** Detects obstacles for parking and close-range navigation.

📌 Step 6: Finalize and Enhance the Drawing

1. **Outline the sketch in pen or marker** for a cleaner look.
2. **Add shading and colors** to differentiate parts of the car.
3. **Ensure all labels and sensor positions are clear and readable.**

📌 Step 7: Review & Submit the Assignment

✓ **Check the sketch for completeness** – Are all sensors included?
✓ **Ensure the labels are clear** and the car design is easy to understand.
✓ **Take a picture or scan the sketch** if submitting digitally.
