

Robotics

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Last checked 30 September 2026

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What you need to know

By the end of this topic you should be able to:

1. **Say what robotics is.** Robotics is the part of computer science that deals with **designing, building** and **operating** robots. Know some examples: robots in factories, robots in the home, and drones.
2. **Describe the characteristics of a robot.** A robot has a **mechanical structure** (a framework), **electrical components** (such as sensors, a microprocessor and actuators), and it is **programmable**.
3. **Describe the jobs robots do, and the advantages and disadvantages of using them, in industry, transport, agriculture, medicine, the home (domestic) and entertainment.**

How a sensor, microprocessor and actuator work together is in the automated systems note; this note shows how to use it when the system is a robot. Robot questions often have extra parts on artificial intelligence and machine learning, firmware, interrupts or data transmission: those are in their own notes.

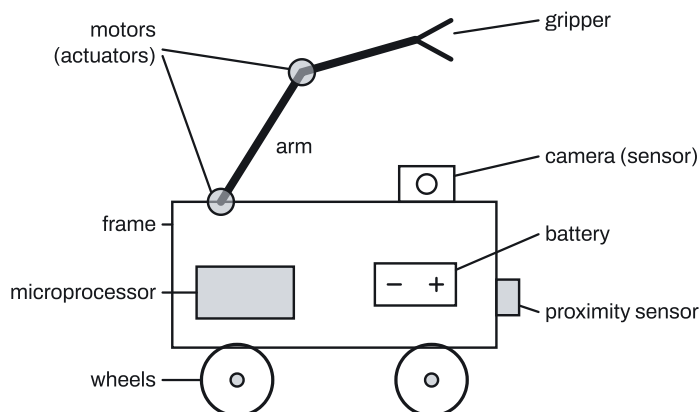
Understand it

Robotics and robots

Robotics is a whole field, not a single machine. It covers the **design** of robots (deciding what a robot must do and planning its parts), their **construction** (building the frame, fitting motors and sensors) and their **operation** (programming and running them to do their tasks). Examiners have noted that many students answer "what is robotics?" by describing a robot; the field is more than that.

A **robot** is a machine that can carry out physical tasks. It is built from a structure you can touch, has electrical parts that sense and move it, and follows a program that people can change.

The three characteristics of a robot



Mechanical structure: frame, wheels, arm, gripper

Electrical components: sensors, microprocessor, motors, battery

Programmable: its program in memory can be changed for a new task

Characteristic	What it means	Examples
Mechanical structure (framework)	The physical body that holds the parts and lets the robot move or handle things	Frame or chassis, wheels, legs, tracks, jointed arm, gripper, propellers
Electrical components	The parts that sense, decide and move	Sensors (proximity, infra-red, camera, pressure, light), a microprocessor , actuators (motors, which make the movements)
Programmable	It follows a set of instructions stored in its memory, and those instructions can be changed so it does a different task	A factory arm reprogrammed for a new product; a warehouse robot given a new route

Because a robot has actuators and a structure, it **can move** (itself, or its parts). "It can move" is accepted as a characteristic too.

Is it a robot? A device that lacks one of these is **not** a robot. A smart doorbell or a laptop has electrical components and runs programs, but has no mechanical structure and no actuators, so it cannot move itself or handle anything: not a robot. A chatbot is only software, so it has neither a body nor electrical parts of its own.

Artificial intelligence is not a characteristic. Many robots just follow fixed instructions and never learn. Examiners have warned that "has AI" does not define a robot. Some robots **also** use AI or machine learning (for example, to learn a route), but that is extra.

How a robot controls its movement

A robot is often an automated system: its **sensors** send data **continuously** to the **microprocessor**; the microprocessor **compares** the data with **stored values**; if action is needed it **sends a signal** to an **actuator** (a motor) that moves the robot or its arm; otherwise no action is taken; and this **repeats** until it is switched off. Readings from analogue sensors are **digitised** (analogue to digital) before the microprocessor uses them.

For a robot, the actions are movements: go forward, stop, turn, lift, grip, lower. The sensors that come up most are **proximity** and **infra-red** (how close something is), **camera** (what is in front), **pressure** (a bump or a weight) and **accelerometer** (tilting or a crash).

What robots do

Area	Roles robots perform
Industry	Welding, spray-painting and assembling products; lifting and moving heavy parts; packing boxes; carrying goods round a warehouse
Transport	Driverless vehicles and trains; loading and unloading cargo and baggage; delivery robots and drones
Agriculture	Planting seeds, weeding, picking fruit, milking cows, spraying crops from drones, self-driving tractors
Medicine	Surgery with robot arms (often worked by a surgeon, who may be far away); lifting patients; dispensing medicines; delivering supplies round a hospital
Domestic	Robot vacuum cleaners, lawn mowers, window and pool cleaners
Entertainment	Moving figures in theme parks, camera drones filming sport and films, robot toys and pets

Advantages and disadvantages

The right answer always depends on **who** the question asks about. Examiners reported in 2023 and 2025 that students give the owner's advantages (such as "robots don't need breaks") when the question asks about the **workers**. For the workers, a robot that never rests is more likely a threat to their job.

Who	Advantages	Disadvantages
The owner or business	Works 24/7 without breaks; faster and more consistent, so more output and fewer errors or less waste; lower wage costs over time; can reach new customers (for example, deliveries to people who can't travel) and so increase sales	Expensive to buy and set up; costly maintenance that needs skilled technicians; staff need training; if it breaks down, work stops or must be done by hand; can't cope with situations it wasn't programmed for; reprogramming for a new task costs money

Who	Advantages	Disadvantages
The workers	Time freed for more interesting, skilled work, or new roles programming and servicing the robots (often better paid after training); the robot takes on the dull jobs done over and over, so the working day is less tiring; the robot handles the hot, toxic, heavy or high-up jobs, so people are hurt less often	May lose their jobs; their skills may no longer be needed (deskilling); may need retraining
Customers, patients or the public	Can be more precise (surgery through smaller cuts, so quicker recovery); services that were hard to reach become available (delivery to the door, a specialist surgeon without travel)	May struggle to use or may distrust the technology, which causes stress; less contact with people; less exercise if they no longer go out (for example, to shop); a fault or a hack could put people in danger

Robots worked from a distance. Some robots are **not** automatic: a person steers them over a network, as when a surgeon in one city works a robot arm in another. Sort the points by who gains or loses:

- **The patient:** the robot's small instruments move more steadily and precisely than a hand, so the cut can be smaller and healing quicker; a rare specialist can operate even if they live on another continent, with no delay while someone flies in.
- **The surgeon:** arrives at the controls rested rather than jet-lagged, and can help several distant hospitals in one week.
- **The hospital:** no fares or hotel bills for visiting specialists; but a very costly machine to buy and service.
- **The risks:** the machine itself can develop a fault mid-operation; and because every instruction travels over a network, a dropped or slow link can halt the operation, while an attacker, or data damaged on the way, could make the arm do the wrong thing and harm the patient.

Key facts and formulas

There are no formulas in this topic and nothing is given in the exam. These are the facts to learn.

Fact	Status
Robotics: the branch of computer science covering the design, construction and operation of robots	Learn it
Robot characteristics: mechanical structure (framework); electrical components (sensors, microprocessor, actuators); programmable. It can move	Learn it
AI is not a characteristic of a robot; some robots use it, many don't	Learn it
Not a robot: no mechanical structure or no actuators, so it can't move itself	Learn it

Fact	Status
Control loop: sensor sends digitised data continuously → microprocessor compares with stored value → signal to actuator (or no action) → repeat	Learn it
Areas: industry, transport, agriculture, medicine, domestic, entertainment	Learn it
Advantages and disadvantages depend on who: owner, workers, or customers/public	Learn it

How to do it

In the Paper 1 questions we have tagged for this topic (8 questions, 2023–2025), the robotics parts came in these types. 7 of the 8 questions mix more than one type, so the counts add up to more than 8. Parts of the same questions on artificial intelligence, firmware, interrupts, networks and data transmission are in their own notes.

Question type	Questions
Characteristics of a robot (and "is it a robot?")	7
Advantages and disadvantages of using robots	6
How a robot's sensors, microprocessor and actuators control it	3
State what is meant by robotics	1

1. Characteristics of a robot (7 questions)

1–3 marks, one per characteristic.

1. **Give the three:** a mechanical structure or framework; electrical components; programmable. "It can move" is a fourth accepted point.
2. **If the question gives one already** ("one characteristic is that it is programmable"), give the **others**, not the same one again.
3. **For "electrical components", name examples:** sensors, a microprocessor, actuators.

Variations you will meet:

- **"Describe the characteristics"** (3 marks): write each one as a short sentence, and add examples if you have fewer than three points ("electrical components, such as sensors and actuators").
- **"Give one other reason why this machine is a robot"**: pick a characteristic the stem hasn't used; add the scenario's example (a camera as an electrical component).
- **"Explain why this device is not a robot"**: say which characteristic is missing: **no mechanical structure, no actuators, so it cannot move** by itself. Having a microprocessor and a program is not enough.
- Don't give "artificial intelligence" or "does tasks humans do" as a characteristic.

2. Advantages and disadvantages of using robots (6 questions)

1. **Underline who** the question is about: the owner, the company, the workers or employees, the customers, the patients, the farmer.
2. **Pick points that help or harm that person** (use the table in "Understand it").
3. **Tie each point to the scenario**: "the workers no longer carry heavy engine parts, so they are less likely to hurt their backs".
4. **"Explain one..."** (2 marks): the point, then its consequence, joined with "so" or "because". **"Explain the advantages"** (4 marks): two points with consequences, or four separate points.

Variations you will meet:

- **A person controls the robot remotely**: the advantages come from not having to travel and from precision, not from "robots never rest".
- **Benefit to a business**: more customers or sales, serving more people at once, lower wage bills, consistent quality.
- **Drawback to customers**: trouble using or trusting the technology, less exercise or human contact, danger if it fails.
- **Two advantages must be different**: "works 24/7" and "doesn't need breaks" count once.

3. How a robot's sensors, microprocessor and actuators control it (3 questions)

5–7 marks, one per step. Use the scenario's **own sensor, stored value and movement**.

1. **Name the sensor** (proximity or infra-red for distance; the question may name it).
2. The sensor **continuously** sends **digitised** data to the microprocessor.
3. The microprocessor **compares** the data with the **stored value** from the question (for example "the stored distance of 50 cm").
4. **If** it is past that value, the microprocessor **sends a signal to the actuator** (a motor) to do the exact movement: stop, turn, brake, lift.
5. **Otherwise** no action is taken, or the robot carries on (say which).
6. If there is a way back (it stopped and the path is now clear), say the microprocessor sends a signal to **start** again.
7. The process **repeats** until the robot is switched off.

Variations you will meet:

- **"Identify one other sensor and how it is used"**: sensor plus use, such as "accelerometer, to detect a crash" or "light sensor, to switch lights on when it gets dark".
- **Detecting a person** within a distance: the data is compared with the stored data for a person **and** the stored distance.

4. State what is meant by robotics (1 question)

2 marks: the branch of computer science dealing with the **design**, the **construction** and the **operation** of robots. Give at least two of the three words; don't describe a robot instead.

Worked examples

The bold codes show where marks are earned, as in Cambridge mark schemes. The number is how many marks.

- **B1** mark for a correct result on its own, with no method needed.

Example 1

A shop sells four products:

- a robotic lawn mower that cuts the grass by itself;
- a smart thermostat that turns a home's heating on and off at set times;
- a chatbot that answers questions on the shop's website;
- a camera drone that flies a pre-planned route and films it.

State whether each product is a robot, giving a reason for each answer. **[4]**

- The lawn mower **is** a robot: it has a mechanical structure (a body, wheels and blades), electrical components (sensors, a microprocessor, motors) and is programmed with where to mow. **B1**
- The thermostat **is not** a robot: it has electrical components and a program, but no mechanical structure or actuators to move, so it cannot move itself. **B1**
- The chatbot **is not** a robot: it is only software, with no mechanical structure or electrical components of its own. **B1**
- The drone **is** a robot: a frame and propellers, motors and sensors, and its route is programmed (and can be changed). **B1**

Example 2

A theme park's ghost-train ride has robotic figures that lunge out of the dark as each car passes. An infra-red beam across the track detects a car, and a motor swings the figure forward and back.

(a) Identify one sensor and one actuator in the ride, and state what each one does. **[2]**

(b) The park could use actors in costume instead of the robotic figures. Evaluate the use of robotic figures instead of actors on this ride. **[3]**

(c) Explain how the change to robotic figures affects the actors differently from the visitors. **[2]**

(a) Sensor: the infra-red sensor, whose readings tell the microprocessor a car has broken the beam. **B1**

Actuator: the motor, which swings the figure out towards the car and back. **B1**

(b) Advantage: every figure performs the same scare at exactly the right moment for every car, all day, with no shifts or wages to pay. **B1** Drawback: the scare never changes, so repeat visitors soon know what is coming, and a figure can't react to a scared child the way an actor can. **B1** A justified choice, for example: the robots, because the ride runs for 12 hours a day and must be the same for every rider, with actors used for special evening events. **B1**

(c) The actors may lose their jobs on the ride or move to other shows, or retrain to look after the figures. **B1** Visitors get the same scare on every ride, but lose the live, unpredictable performance, so repeat visits may feel less exciting. **B1**

Example 3

A warehouse uses robots that drive under a shelf unit, lift it and carry it to a packing desk. A pressure sensor under each robot's lifting plate measures the weight of the load. A robot must not carry more than 400 kg: if the load is heavier, it lowers the shelf again and sends a message to the supervisor's tablet.

(a) The robots are programmable. Explain why this is useful to the warehouse. **[2]**

(b) Describe how the pressure sensor and the microprocessor make sure a robot never carries more than 400 kg. **[5]**

(c) Explain one advantage to the warehouse's pickers, who used to fetch items from the shelves by walking round the warehouse. **[2]**

(a) The instructions in the robots' memory can be changed **B1**, so when the warehouse changes its layout or its routes, the robots can be given new routes without buying new robots. **B1**

(b) Any five:

- the pressure sensor continuously sends its readings to the microprocessor, digitised by an ADC **B1**;
- the microprocessor converts the reading into a weight and compares it with the stored value of 400 kg **B1**;
- if the weight is more than 400 kg, it sends a signal to the actuator (the lifting motor) to lower the shelf **B1**;
- and it sends a message to the supervisor's tablet **B1**;
- if the weight is 400 kg or less, no action is taken and the robot carries the shelf **B1**;
- this repeats continuously while the robot is working **B1**.

(c) The shelves come to the pickers, so they no longer walk long distances carrying items all day **B1**, so they are less tired and less likely to be injured, and can spend the time packing more orders or on more skilled tasks. **B1**

Common mistakes

- **Describing a robot when asked about robotics.** Robotics is the field: design, construction and operation of robots.
- **Giving "artificial intelligence" as a characteristic.** Many robots have no AI; it does not define a robot.
- **Repeating the characteristic in the stem.** If the question already says "it is programmable", that answer earns nothing.
- **Saying something is not a robot "because it isn't clever enough".** Say what is missing: no mechanical structure, no actuators, so it cannot move.
- **Answering for the wrong person.** "Robots don't need breaks" helps the owner, not the workers; the examiner reports for 2023 and 2025 both point this out.
- **Generic answers.** "It is faster and cheaper" earns little. Say how it helps in the scenario: for a surgeon controlling a robot remotely, the advantage is that no one has to travel, not that the robot never gets tired.
- **Letting the sensor decide, or saying it sends data only when it detects something.** The sensor sends data continuously; the microprocessor compares and decides; the actuator moves.
- **Repeating the question** ("if the object is closer than 50 cm, the robot stops"). Show the steps: the reading is compared with the stored 50 cm, and if it is less, a signal goes to the actuator to stop.

How to get the marks

- **"Give" / "State" / "Identify"** (1 mark each): one precise term, such as "mechanical structure" or "actuator". Separate answers must be different.
- **"Describe the characteristics"**: each characteristic is a mark; examples of electrical components (sensors, microprocessor, actuators) can earn a mark when you are short of points.
- **"Explain why ... is (not) a robot"**: link the missing or present characteristics to the device, and finish with what that means (it cannot move itself).
- **"Explain one advantage/drawback"** (2 marks): the point **and** its consequence for the named person in the scenario.
- **"Describe how the sensor and microprocessor..."**: one mark per step, using the question's own values and movement; end with "the process repeats".
- **Read the context.** Examiners reward answers that could only be about this robot and these people.

Quick check

1. A student writes: "Robotics is a machine that can do tasks automatically." Explain what is wrong, and give a correct description of robotics.
2. A crop-spraying drone flies over fields and sprays fertiliser. Give an example from the drone of each of the three characteristics of a robot.
3. A robot vacuum cleaner follows the same fixed cleaning pattern every day and never changes it. Is it still a robot? Explain your answer.

4. A hospital buys a robot that lifts patients from their beds into wheelchairs. Give one advantage to the nurses, and one different advantage to the hospital managers.
5. A lawn-mowing robot follows these rules: "If the proximity reading is 30 cm or less, stop the blade motor and turn. Otherwise, if the battery is below 20%, return to the dock. Otherwise keep mowing." Say what it does for each pair of readings (distance, battery): (120 cm, 64%), (30 cm, 63%), (85 cm, 21%), (200 cm, 19%).

Answers

1. It describes a robot (a machine), not robotics. Robotics is the branch of computer science that deals with the design, construction and operation of robots.
2. Mechanical structure: its frame and propellers. Electrical components: for example its GPS receiver or camera (sensors), its microprocessor, and the motors that spin the propellers and open the spray valve (actuators). Programmable: its flight route and spraying rate are set by a program that can be changed for a different field.
3. Yes. It has a mechanical structure (body, wheels, brushes), electrical components (sensors, microprocessor, motors) and it is programmable. It doesn't need to learn or use AI to be a robot.
4. Nurses: they no longer lift patients by hand, so they are less likely to injure their backs. Managers: fewer staff injuries means fewer staff off sick and fewer compensation claims (or: patients can be moved at any time without waiting for two nurses to be free).
5. (120, 64): more than 30 cm and battery not low, so keep mowing. (30, 63): 30 cm or less, so stop the blade and turn. (85, 21): 21% is not below 20%, so keep mowing. (200, 19): below 20%, so return to the dock.

Past questions to try

- **0478/11/M/J/23 Q9**: characteristics, then advantages to employees and a disadvantage to owners.
- **0478/12/F/M/23 Q6**: what robotics means, and how a robot's sensor and microprocessor make it turn.
- **0478/12/F/M/24 Q6**: a self-driving tractor that must stop near a person, and its drawbacks.