PrepWithTee

NOTES

Automated and Emerging Technologies

Cambridge IGCSE Computer Science (0478)

The full notes for this chapter: the topic taught from the basics, then how it is examined - question types, marking points, keywords and real past-paper questions solved - with practice to finish.

Contents

1 **Automated systems** 11 min

2 **Robotics** 12 min

3 **Artificial intelligence** 13 min

Each note has two parts. **Part 1** teaches the topic from the basics. **Part 2** shows how it is examined: the types of question, what the examiner gives marks for, the keywords to use, and real past-paper questions solved with the official mark scheme. The answers to every practice question are at the end of each note.

NOTE 1

Automated systems

1 In this note

SYLLABUS 6.1 AUTOMATED SYSTEMS

- 6.1.1 Describe how **sensors**, **microprocessors** and **actuators** can be used in collaboration to create **automated systems**.
- 6.1.2 Describe the **advantages and disadvantages** of an automated system used for a given purpose: industry, transport, agriculture, weather, gaming, lighting, science.

Before this: Sensors (chapter 3). Next: Robotics.

PART 1

Learn the topic

The notes: every idea from the start, with our own examples.

2 What you should already know

Sensors

A sensor is an input device that measures a physical property (temperature, light, distance…) and sends the reading as data, after an ADC turns it into digital form.

Quick check: does a sensor make decisions?

No: the microprocessor does.

Microprocessor

An integrated circuit that processes data: here it runs the control program.

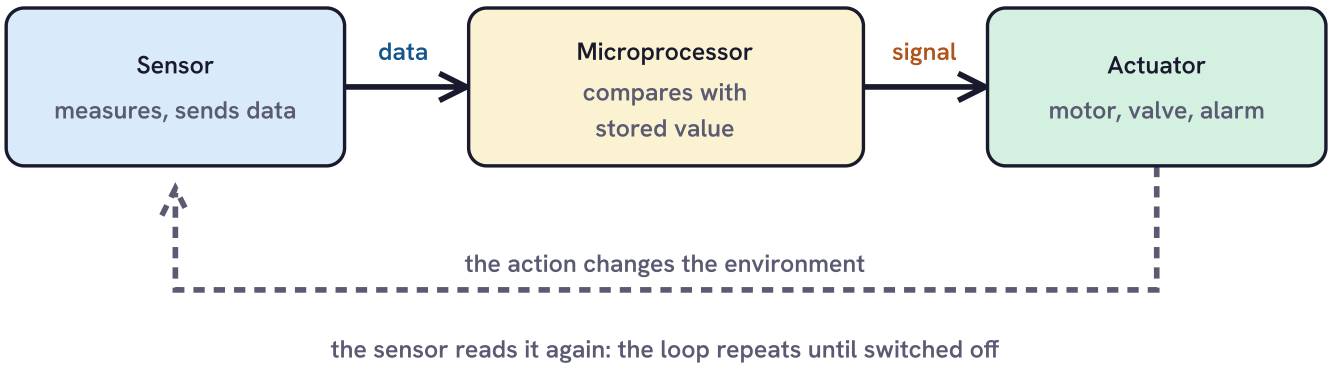
Quick check: where is the control program kept?

In ROM, as firmware.

3 What is an automated system?

Automated system: a system that can **perform actions without human intervention**. It is made of **sensors**, a **microprocessor** and **actuators** working together.

Part	Its job
Sensor	**measures** something in the environment and **sends the reading (data) to the microprocessor**
Microprocessor	**receives** the data, **compares it with a stored / preset value or range**, **decides** what to do and **sends a signal** to the actuator
Actuator	a component that **makes something move or happen** when it gets a signal: a motor, a valve, a pump, a heater, a light, a buzzer



Sensor, microprocessor and actuator working together in a loop.

✗ COMMON MISTAKE

The **sensor does not decide anything** and does not "tell the actuator". Marks are for the **microprocessor** comparing and sending the signal.

4 How it works, step by step

GENERAL METHOD **Describe how an automated system works (any scenario)**

1. Name the **sensor** that fits (e.g. temperature, proximity / infra-red, light, moisture, pressure).
2. The sensor **continuously** sends **digitised data** (readings) to the **microprocessor**.
3. The microprocessor **compares the data with the stored value** (give the number from the question, e.g. 40 °C, 10 cm).
4. **If** the reading is outside the range / past the value, the microprocessor **sends a signal to the actuator** to act (name the action).
5. **If** it is within the range, **no action** is taken (or the current action carries on).
6. The process **repeats continuously** until the system is switched off.

EXAMPLE: SMART HEATING **A room is kept at 21 °C. Describe how the heating system works. [5]**

Follow the method: sensor → microprocessor compares → actuator → repeat.

A **temperature sensor** continuously sends digitised readings to the **microprocessor**.

The microprocessor compares each reading with the stored value of 21 °C.

If the reading is below 21 °C, it sends a signal to an **actuator** to switch the heater on.

If the reading is 21 °C or above, it sends a signal to switch the heater off.

This repeats until the system is switched off.

ANSWER

Sensor → microprocessor compares with stored value → signal to actuator → repeat.

TRY IT YOURSELF

1. Which part compares a reading with a stored value?
2. Name the component that makes something move, e.g. a motor.

3 An automated street light turns on when it gets dark. Which sensor does it use?

5 Where automated systems are used

The syllabus names seven settings. In the exam you get a scenario and must give advantages and disadvantages **for that scenario** and **for the person named** (the employees, the owner, the farmer, the customer).

Setting	Example	Sensors → actuator
Industry	a bottling line fills and caps bottles	level / proximity → valve, motor
Transport	a driverless train stops at the platform; car parking sensors	proximity / infra-red → brakes, buzzer
Agriculture	automatic irrigation; a self-driving plough or tractor	moisture, proximity → pump, motor
Weather	a weather station records and alerts	temperature, humidity, pressure, light → stored data, alert
Gaming	a motion controller or VR headset reacts to movement	accelerometer, gyroscope → screen, vibration motor
Lighting	street lights or room lights switch themselves on	light, infra-red (motion) → lights
Science	a lab experiment logs readings overnight	temperature, pH, gas → stored readings, heater

6 Advantages and disadvantages

Advantages	Disadvantages
faster and more **accurate / consistent** than a person	**expensive to set up** (buy, install)
works 24/7, no breaks, no tiredness	**ongoing maintenance / repair costs**; needs skilled people to fix
safer: people don't go into **dangerous** places or handle heavy loads	can **malfunction**: production stops, or it fails to act (e.g. doesn't stop)
takes over **boring, repetitive** tasks; staff can do **more skilled** work	**deskilling** and **job losses**; staff need **training**
saves labour costs over time	**can't adapt** to an unexpected event it wasn't programmed for
creates new **maintenance** jobs	can be **hacked** if it is connected to a network

> Write the advantage **for the person the question names** and **explain** it: "employees don't need to go into dangerous areas to take readings, **so they are safer**" earns 2; "it is safer" earns at most 1.

7 Summary

- Automated system: performs actions without human intervention.
- Sensor sends data → microprocessor compares with stored value → signal to actuator → repeats.
- Settings: industry, transport, agriculture, weather, gaming, lighting, science.
- Advantages: 24/7, accurate, safer, no repetitive work. Disadvantages: cost, maintenance, malfunction, deskilling, job loss.

IF YOU SEE …

"explain how the sensor and the microprocessor are used to automate this" [5-7]	→ name sensor · continuously sends data · microprocessor compares with stored value · if… signal to actuator · if not… · repeats
"give two advantages to the employees" [2]	→ safety · no repetitive tasks · no heavy lifting · no night work · new maintenance jobs

PART 2

How it is examined

Question types, what the examiner gives marks for, and real past-paper questions solved.

8 Ways they test it

TYPE 1 **Explain the process**

> *"Explain how the sensor, microprocessor and actuator are used to stop the tractor" [5-7]*

Spot it a scenario with a number (3 m, 40 °C, 10 cm).

1. Follow the method; repeat the number from the question.

TYPE 2 **Role of a part**

> *"Describe the role of the microprocessor in this process" [3]*

Spot it "role".

1 receives data · compares / checks the range · sends signals to trigger actions

TYPE 3 **Advantages / disadvantages**

> *"Give two advantages to the employees..." [2]; "Explain one disadvantage to the owner" [2]*

Spot it who it is for.

1 Point for that person + its matching explanation.

TYPE 4 **Definition / components**

> *"State what is meant by an automated system" [1]; "give one other component" [1]*

Spot it "what is meant by".

1 without human intervention; microprocessor · actuator · storage

9 What the examiner looks for

"Explain how the sensor and microprocessor are used to automate the system" [5-7]

Marking points (one mark each, up to the marks shown)

- Names a suitable sensor (e.g. infra-red / proximity)
- Sensor continuously sends the digitised value to the microprocessor
- Microprocessor compares the data with the stored value (the number given)
- If past the value, a signal is sent to the actuator to act
- If not, no action / carries on
- The process repeats until switched off

KEYWORDS **continuously** **digitised** **compares** **stored value** **signal** **actuator** **repeats**

TOO VAGUE "the sensor decides"; "the sensor tells the motor"

10 Past-paper questions, solved

0478/13/O/N/24 Q5 ↗ Paper 1 · Computer systems **6 marks** ⤢ Full size

5 A farmer has a plough that is an automated system. The plough is used to dig the ground in a field to prepare it for planting seeds.

The plough uses sensors and a microprocessor to maintain a straight line when digging the ground.

(a) State what is meant by an automated system.

..... [1]

(b) Describe the role of the microprocessor in this process.

..... [3]

(c) Give **two** benefits to the farmer of using an automated system for this purpose.

[2]

Swipe sideways to read the whole question

How to start (a) a definition [1]; (b) three things the microprocessor does [3]; (c) two benefits for the farmer [2]. Part (d), on AI, is solved on the AI page.

▼ Show a full-mark answer and the mark scheme · official marking

WHAT TO WRITE

(a) A system that can perform actions without human intervention.

(b) It receives data from the sensors. It checks whether the data is within the range for a straight line. If it is out of range, it sends signals to trigger an action to steer the plough back.

(c) The farmer doesn't have to handle heavy equipment; it can work 24/7 without breaks.

PART	ANSWER / WORKING	MARKS	GUIDANCE
5(a)	Performs actions without human intervention	B1	
5(b)	receives data from sensor · analyses / checks if within range · sends signals to trigger actions	B3	
5(c)	Any two: no heavy equipment · frees farmer for other jobs · 24/7 · repetitive tasks · saves labour · more accurate / efficient	B2	

Total: 6 marks

6 A weather station uses automated systems to collect and analyse data about the weather.

The automated system uses sensors.

(a) Give **one** other component that would be part of the automated system.

..... [1]

(b) One sensor that is part of the automated system is a temperature sensor.

Give **one** other sensor that could be part of the automated system.

..... [1]

(c) An alert is sent to an employee in the weather office if a temperature above 40 °C is detected.

(i) Explain how a temperature above 40 °C is detected for the alert.

..... [3]

(d) Give **two** advantages to the weather station employees of using an automated weather system.

[2]

(e) Give **one** disadvantage to the weather station employees of using an automated weather system.

..... [1]

Swipe sideways to read the whole question

How to start (a) a part other than sensors; (b) another sensor; (c)(i) the process with 40; (d) and (e) for the employees. (c)(ii) is data transmission (chapter 2).

▼ Show a full-mark answer and the mark scheme · official marking

WHAT TO WRITE

(a) A microprocessor (or an actuator).

(b) Humidity sensor.

(c)(i) The microprocessor receives data from the temperature sensor. It compares the data with the preset value of 40. If the data is greater than 40, it sends a signal to trigger the alert.

(d) Employees don't need to work outside in bad weather; they don't need to work overnight.

(e) It may replace employees and take their jobs.

PART	ANSWER / WORKING	MARKS	GUIDANCE
6(a)	Any one: microprocessor · actuator · storage	**B1**	
6(b)	Any one: humidity · light · level · infra-red	**B1**	
6(c)(i)	microprocessor used · receives data from sensor · compares with 40 · greater than 40 → signal to trigger alert	**B3**	
6(d)	Any two: no repetitive task · no overnight work · not outside in bad weather · maintenance jobs	**B2**	
6(e)	Any one: deskilling · replaces employees	**B1**	

Total: 8 marks

0478/12/O/N/23 Q11 ↗ Paper 1 · Computer systems **5 marks** ⤢ Full size

11 A manufacturing company uses an automated system in its manufacturing process.

(a) The automated system uses a flow sensor.

Identify what a flow sensor measures.

.....

..... [1]

(b) Explain **one** advantage to employees of using an automated system in manufacturing.

.....

.....

.....

..... [2]

(c) Explain **one** disadvantage to the company owner of using an automated system in manufacturing.

.....

.....

.....

..... [2]

Swipe sideways to read the whole question

How to start (b) and (c) say **explain one** : a point + its matching explanation, 2 marks each.

▼ **Show a full-mark answer and the mark scheme** · official marking

WHAT TO WRITE

(a) The amount of liquid or gas flowing through a pipe.

(b) It increases safety, because workers don't need to go into dangerous areas to take readings or make checks.

(c) High set-up cost, so the owner must find a lot of money up front to pay for the equipment and train employees.

PART	ANSWER / WORKING	MARKS	GUIDANCE
11(a)	Amount of liquid / gas / steam flowing	**B1**	
11(b)	Benefit + matching explanation, e.g. safety → no need to enter dangerous areas; no repetitive tasks → more skilled work	**B2**	
11(c)	Drawback + matching explanation, e.g. high set-up cost → money up front; maintenance cost → skilled staff needed	**B2**	
		Total: 5 marks	

11 Common mistakes

✗ "The sensor checks if it is too hot"

✓ "The microprocessor compares the reading with the stored value"

Sensors only measure.

✗ "The sensor sends a signal to the motor"

✓ "The microprocessor sends a signal to the actuator"

✗ "It is cheaper" (one-word answers)

✓ "It saves labour costs because no workers need to be paid to ..."

Explain = point + reason.

✗ Forgetting the loop

✓ "This repeats until the system is switched off"

It is a mark on most schemes.

12 Practice

Practice: easy, medium, hard

1. State what is meant by an automated system. [1]
2. Give one example of an actuator.
1. An automatic door opens when a person is within 2 m. Explain how it works. [5]
2. Give two disadvantages to a factory owner of an automated system. [2]
1. A science lab keeps a reaction between 60 °C and 65 °C overnight. Explain how an automated system does this and give one advantage to the scientists. [6]

13 Can I do this?

0 / 3 ticked

- [ ] I can say what each of the sensor, microprocessor and actuator does.
- [ ] I can explain step by step how an automated system works in a scenario.
- [ ] I can give advantages and disadvantages for the person named.

Anything unticked: revise that section first (each line links to it). All ticked: take the quiz.

Answers

Answers to the "Try it yourself" and practice questions on this page. Try every question first.

Try it yourself 1

1.

ANSWER The microprocessor

2.

ANSWER Actuator

3.

ANSWER Light sensor

Practice: easy, medium, hard

Easy 1.

ANSWER A system that performs actions without human intervention

Easy 2.

ANSWER e.g. motor · valve · pump · heater · buzzer

Medium 1.

ANSWER

Infra-red / proximity sensor continuously sends data to the microprocessor · compares with stored 2 m · if within 2 m, signal to actuator (motor) to open · if not, door stays shut / closes · repeats

Medium 2.

ANSWER e.g. high set-up cost · maintenance cost · production stops if it malfunctions

Hard 1.

ANSWER

Temperature sensor sends data continuously · microprocessor compares with 60 and 65 · below 60 → signal to heater on · above 65 → heater off · repeats · advantage: scientists needn't stay overnight to check readings, and readings are taken more accurately

NOTE 2

Robotics

1 In this note

SYLLABUS 6.2 ROBOTICS

- 6.2.1 Understand what is meant by **robotics**: a branch of computer science that incorporates the **design, construction and operation** of robots, e.g. factory equipment, domestic robots, drones.
- 6.2.2 Describe the **characteristics of a robot**: a mechanical structure or framework, electrical components, programmable.
- 6.2.3 Understand the **roles** that robots can perform and describe the **advantages and disadvantages** of their use in industry, transport, agriculture, medicine, domestic and entertainment.

Before this: Automated systems. Next: Artificial intelligence.

PART 1

Learn the topic

The notes: every idea from the start, with our own examples.

2 What you should already know

Automated systems

Sensor → microprocessor compares with a stored value → signal to an actuator → repeats.

Quick check: which part decides?

The microprocessor.

Firmware

Permanent instructions stored in ROM that control the hardware.

Quick check: where is a robot's program kept?

In ROM, as firmware.

3 What is robotics?

> **Robotics**: a branch of computer science that covers the **design**, **construction** and **operation** of **robots**.

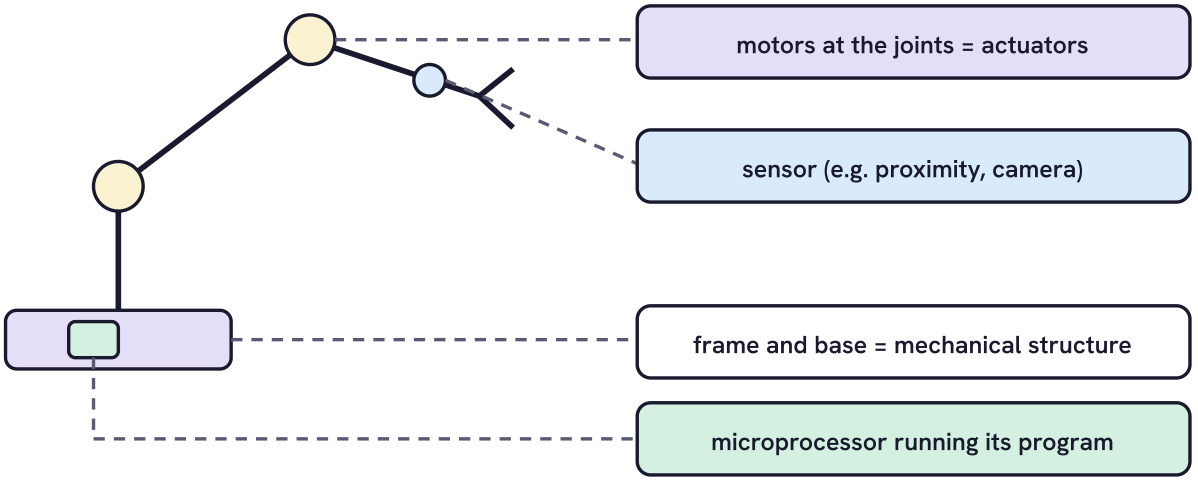
Examples you can quote: **factory equipment** (welding and painting arms on a car production line), **domestic robots** (robot vacuum cleaners, lawn mowers) and **drones** (delivery, filming, crop spraying).

4 The characteristics of a robot

A machine is only a **robot** if it has all three of these:

Characteristic	What it means	Example
Mechanical structure / framework	a physical body, often with wheels, arms, joints or grippers, so it **can move** and do a physical task	the arm and base of a welding robot
Electrical components	**sensors** (to collect data), a **microprocessor** (to process it) and **actuators** (motors to move)	a proximity sensor, a microprocessor, joint motors
Programmable	it is controlled by a **program** that can be written or changed, so it can be given a new task	reprogrammed to weld a new car model

a robot = mechanical structure + electrical parts + programmable



A factory robot arm and its three characteristics.

Is it a robot? A **smart speaker** is **not**: it has no mechanical structure and no actuators, so it cannot move itself. A **self-driving tractor** is: it has a framework, electrical components and is programmable.

TRY IT YOURSELF

1. One characteristic of a robot is that it is programmable. Name another.
2. Robotics covers the design, construction and … of robots.
3. Give two electrical components a robot has.

5 How a robot reacts to its surroundings

A robot is an automated system, so the **same method** earns the marks when a question asks how it avoids an obstacle, stops for a person or turns at a fence.

GENERAL METHOD **Explain how a robot uses its sensor and microprocessor**

1. A **proximity / infra-red** sensor (or the sensor that fits) is used.
2. The sensor **continuously sends digitised data** to the **microprocessor**.
3. The microprocessor **compares the data with the stored value** (e.g. 10 cm, 3 m).
4. **If** the object is at or within the value, it **sends a signal to an actuator** to stop / turn / brake.
5. **Otherwise** it sends a signal to carry on (move forward) or takes no action.
6. This **repeats** until the robot is turned off.

6 Roles robots perform

Area	Roles	Advantages	Disadvantages
Industry	welding, painting, assembling, moving heavy parts, packing	works 24/7; consistent quality; workers do no heavy lifting or dangerous work	expensive to buy and maintain; job losses; stops production if it breaks
Transport	driverless cars, trains and delivery vehicles; warehouse robots	fewer accidents from human error; works without breaks	can fail to recognise a hazard; can be hacked; job losses for drivers
Agriculture	planting seeds, ploughing, harvesting, weeding, crop-spraying drones	more accurate planting; 24/7; farmer is free for other jobs	expensive; needs maintenance; can't adapt to an unexpected event; farmer needs training
Medicine	surgery controlled by a doctor (even from far away); dispensing medicine	more precise, so smaller cuts and faster recovery; a specialist anywhere can operate without travelling	connection can be lost or delayed; can be hacked; very expensive
Domestic	robot vacuum cleaners, lawn mowers, pool cleaners	saves people time on repetitive chores	expensive; can get stuck; may not clean as thoroughly
Entertainment	theme-park rides, animatronics, camera robots and drones for filming	repeats a show exactly; films shots a person can't	expensive; can malfunction mid-show; less of a human touch

✗ COMMON MISTAKE

Read **whose** advantage it is. "Advantages to the **workers**": no heavy lifting, safer, no repetitive tasks, new maintenance jobs. "To the **company**": no wages, 24/7, consistent. They are different mark lists.

7 Summary

- Robotics: the design, construction and operation of robots (factory equipment, domestic robots, drones).
- A robot: mechanical structure / framework + electrical components (sensors, microprocessor, actuators) + programmable.
- It reacts using the automated-system loop: sensor → microprocessor compares → actuator → repeat.
- Roles in industry, transport, agriculture, medicine, domestic, entertainment, each with advantages and disadvantages.

IF YOU SEE …

"give three characteristics of a robot" [3]	→ mechanical structure / framework · electrical components · programmable · (can move)
"explain why X is not a robot" [3]	→ no mechanical structure · no actuators · so it cannot move itself

PART 2

How it is examined

Question types, what the examiner gives marks for, and real past-paper questions solved.

8 Ways they test it

TYPE 1 Characteristics

> *"One characteristic is that it is programmable. State two other characteristics" [2]*

Spot it a characteristic already given.

1. Don't repeat the one in the question.

TYPE 2 **Robot or not?**

> *"Explain why the smart speaker is not a robot" [3]*

Spot it "not a robot".

1. Say which characteristic is missing and what it means.

TYPE 3 **Sensor process**

> *"Explain how the robot uses sensors and a microprocessor to know it has reached a fence" [6-7]*

Spot it a distance or event.

1. The method above, with the value from the question.

TYPE 4 **Advantages / disadvantages**

> *"Give two advantages to the farmer..." [2]; "explain the advantages of using the robot to perform surgery" [4]*

Spot it whose and how many.

1. For "explain", each point + its "so...".

9 What the examiner looks for

"Describe the characteristics of a robot" [3]

Marking points (one mark each, up to the marks shown)

- A mechanical structure / framework
- Electrical components
- ... such as sensors / microprocessor / actuators
- Programmable
- Has the ability to move

KEYWORDS **mechanical structure** **framework** **electrical components** **programmable**

TOO VAGUE "it is intelligent" (that is AI, not a characteristic of a robot); "it is automatic"

10 Past-paper questions, solved

0478/11/M/J/24 Q8 ↗ Paper 1 · Computer systems **16 marks** ⤢ Full size

8 A farmer uses an automated robot to plant seeds in the field.

(a) State what is meant by the robot being automated.

..... [1]

(b) Give **three** characteristics of a robot.

[3]

(c) The robot plants seeds and stops when it reaches a fence. It then turns and continues planting seeds. The robot uses sensors and a microprocessor to know when it reaches a fence.

Explain how the robot uses sensors and a microprocessor to know it has reached a fence.

..... [6]

(d) Give **two** advantages of the farmer using an automated robot to plant seeds.

[2]

(e) Give **two** disadvantages of the farmer using an automated robot to plant seeds.

[2]

(f) The robot is adapted to have machine learning capabilities.

Explain how this will improve the robot.

..... [2]

Swipe sideways to read the whole question

How to start Six parts: (a) automated [1], (b) characteristics [3], (c) the sensor process [6], (d)/(e) for the farmer [2+2], (f) machine learning (next note) [2].

▼ **Show a full-mark answer and the mark scheme** · official marking

WHAT TO WRITE

(a) The robot can perform actions without human intervention.

(b) It has a mechanical structure / framework; it has electrical components; it is programmable.

(c) A proximity sensor is used. It continuously sends digitised data to the microprocessor. The microprocessor compares the data with a stored range of values. If the value is within the range, the robot carries on planting. If it is outside the range (the fence is reached), the microprocessor sends a signal to an actuator to stop and turn the robot. This repeats until the robot is turned off.

(d) It is more accurate when planting seeds; it does not need breaks, so it can work 24/7.

(e) It is expensive to buy; it needs maintenance, which may be costly.

(f) It can change its own rules and data, so it remembers where the fence and obstacles are and makes fewer errors.

PART	ANSWER / WORKING	MARKS	GUIDANCE
8(a)	Performs actions without human intervention	**B1**	
8(b)	Any three: mechanical structure / framework · electrical components · programmable · can move	**B3**	
8(c)	proximity sensor · sends digitised data continuously · compares with stored value / range · within range → continues · outside → signal to turn / stop · using an actuator · repeats	**B6**	
8(d)	Any two: more accurate · 24/7 · not bored · farmer does other tasks · faster · safer · no wages	**B2**	
8(e)	Any two: expensive · maintenance cost · job losses · deskilling · training · manual if it breaks · damage if faulty · can't adapt	**B2**	
8(f)	adapts its own rules / data / processes · more efficient · … e.g. remembers where the fence / obstacles are · fewer errors	**B2**	
			Total: 16 marks

6 A self-driving tractor sows seeds and harvests crops for a farmer. The self-driving tractor moves automatically through the field, turning at each end and stopping when it has finished.

(a) One reason the self-driving tractor is a robot is because it has a mechanical structure that includes wheels, an engine, and a framework.

Give **one** other reason why the self-driving tractor is an example of a robot.

..... [1]

(b) If a person is detected within 3 metres whilst the tractor is moving, the self-driving tractor must stop.

(i) Explain how an infra-red sensor, microprocessor and actuator can be used to stop the self-driving tractor if a person is detected within 3 metres.

..... [5]

(ii) Identify **one** other sensor that the self-driving tractor might use and how it will use the sensor.

Sensor .....

Use .....

[2]

(c) Explain the drawbacks of a farmer using a self-driving tractor to sow seeds and harvest crops.

..... [3]

Swipe sideways to read the whole question

How to start (b)(i) needs all three named parts; (c) says **explain the drawbacks** : points with reasons. (d) and (e) are expert systems and error checking.

▼ Show a full-mark answer and the mark scheme · official marking

WHAT TO WRITE

(a) It is programmable (or: it has electrical components).

(b)(i) The infra-red sensor continuously sends the digitised readings to the microprocessor. The microprocessor compares the data with the stored data for a person and the distance of 3 m. If a person is within 3 m, it sends a signal to the actuator to apply the brakes and stop the tractor. If not, no action is taken. The process repeats until the tractor is turned off.

(b)(ii) A proximity sensor, to detect when it is near the end of the field so it can turn.

(c) The set-up cost may be high. Maintenance needs skilled experts, which is costly. It can malfunction and fail to recognise a person, so it does not stop.

PART	ANSWER / WORKING	MARKS	GUIDANCE
6(a)	Any one: electrical components · programmable	**B1**	
6(b)(i)	Any five: sensor sends data continuously · microprocessor compares with stored data / 3 m · if person within 3 m · signal to actuator to stop / brake · if more than 3 m no action · restart when clear · repeats	**B5**	
6(b)(ii)	Sensor + matching use, e.g. accelerometer → uneven ground / crash; proximity → end of field; light → headlights	**B2**	
6(c)	Any three: set-up cost · maintenance cost · needs experts · retraining · deskilling · fewer employees · malfunction → fails to stop	**B3**	
		Total: 11 marks	

5 A hospital has computers and technology that it uses when caring for its patients.

(b) The hospital has a robot that is used to perform surgery. A doctor controls the robot from a different location to perform surgery on a patient.

(i) One feature of the robot is that it has electrical components.

Give **two** examples of the electrical components of a robot.

[2]

(ii) Explain the advantages of using the robot to perform surgery.

..... [4]

(iii) Explain **one** disadvantage of using the robot to perform surgery.

..... [2]

Swipe sideways to read the whole question

How to start (ii) **explain the advantages** [4]: two advantages, each with its "so...". (iii) one disadvantage + its consequence [2].

▼ **Show a full-mark answer and the mark scheme** · official marking

WHAT TO WRITE

(b)(i) Sensors; actuators (or a microprocessor).

(ii) The doctor does not need to travel to the hospital, so any specialist in the world can do the surgery and it can be done immediately. The robot is more precise, so a smaller incision can be made and the recovery time is shorter.

(iii) The internet connection could be lost or delayed, so the surgery may not be able to continue.

PART	ANSWER / WORKING	MARKS	GUIDANCE
5(b)(i)	Any two: sensors · microprocessors · actuators	B2	
5(b)(ii)	no travel · … any specialist · … done immediately · … not tired · precision · … smaller incision · … shorter recovery · safer	B4	
5(b)(iii)	Point + expansion, e.g. connection lost → surgery stops; hacked → endangers patient; malfunction → cannot continue	B2	

Total: 8 marks

0478/12/O/N/25 Q7 ↗ Paper 1 · Computer systems — **3 marks** — ⤢ Full size

7 A house has a smart speaker that can take voice commands as input. A person in the house can tell the smart speaker to play music or audio books.

(a) The smart speaker cannot be described as a robot.

Explain why the smart speaker is **not** a robot.

..... [3]

Swipe sideways to read the whole question

How to start Use the three characteristics: which ones are missing?

▾ **Show a full-mark answer and the mark scheme** · official marking

WHAT TO WRITE

It does not have a mechanical structure. It does not have any actuators, so it cannot move itself.

PART	ANSWER / WORKING	MARKS	GUIDANCE
7(a)	no mechanical structure · no actuators · so it cannot move itself	B3	

Total: 3 marks

11 Common mistakes

✗ "A robot is intelligent"

✓ "A robot has a mechanical structure, electrical components and is programmable"

AI is a separate idea; not every robot has it.

✗ "It has a sensor" as the characteristic

✓ "It has electrical components, such as sensors"

Name the characteristic first.

✗ Repeating the characteristic given in the question

✓ Give the other ones

No mark for the one they gave you.

✗ "The robot is cheaper"

✓ "The company does not need to pay wages to workers"

Explain the point.

12 Practice

Practice: easy, medium, hard

1. Give three characteristics of a robot. [3]
2. Give one example of a domestic robot. [1]
3. A drone delivers parcels. Give two advantages to the delivery company. [2]
4. Explain why a robot vacuum cleaner is a robot. [3]
5. A robot moves forward until an object is 15 cm in front, then turns left. Explain how it uses its sensor and microprocessor. [6]

13 Can I do this?

0 / 4 ticked

- [ ] I can say what robotics is, with examples.
- [ ] I can give the three characteristics of a robot and say why something is not a robot.
- [ ] I can explain how a robot reacts using its sensor, microprocessor and actuator.
- [ ] I can give roles, advantages and disadvantages in the six areas.

Anything unticked: revise that section first (each line links to it). All ticked: take the quiz.

Answers

Answers to the "Try it yourself" and practice questions on this page. Try every question first.

Try it yourself 1

1.

ANSWER A mechanical structure / framework (or electrical components)

2.

ANSWER Operation

3.

ANSWER Sensors and actuators (or a microprocessor)

Practice: easy, medium, hard

Easy 1.

ANSWER Mechanical structure / framework · electrical components · programmable

Easy 2.

ANSWER e.g. robot vacuum cleaner · robot lawn mower

Medium 1.

ANSWER e.g. no driver wages · faster deliveries (not stuck in traffic) · works 24/7

Medium 2.

ANSWER

It has a mechanical structure (body, wheels, brushes) so it can move · it has electrical components (sensors, microprocessor, motors) · it is programmable

Hard 1.

ANSWER

Proximity / infra-red sensor · continuously sends digitised data to the microprocessor · compares with 15 cm · if greater than 15 cm, signal to actuator to move forward · if 15 cm or less, signal to actuator to turn left · repeats until turned off

NOTE 3

Artificial intelligence

1 In this note

SYLLABUS 6.3 ARTIFICIAL INTELLIGENCE

- 6.3.1 Understand what is meant by **artificial intelligence (AI)**: a branch of computer science dealing with the **simulation of intelligent behaviours** by computers.
- 6.3.2 Describe the **main characteristics** of AI: the collection of data and the rules for using that data; the ability to reason; it can include the ability to learn and adapt.
- 6.3.3 Explain the basic operation and components of AI systems: **expert systems** (knowledge base, rule base, inference engine, interface) and **machine learning** (a program that can automatically adapt its own processes and/or data).

Before this: Robotics. This is the last note of Paper 1 theory.

PART 1

Learn the topic

The notes: every idea from the start, with our own examples.

2 What you should already know

Robots

Mechanical structure + electrical components + programmable. A robot does not have to be intelligent.

Quick check: does every robot have AI?

No: AI is something extra some robots have.

3 What is AI?

Artificial intelligence (AI): a branch of computer science dealing with the **simulation of intelligent behaviours** by computers, so a computer can do things that would need

intelligence if a person did them.

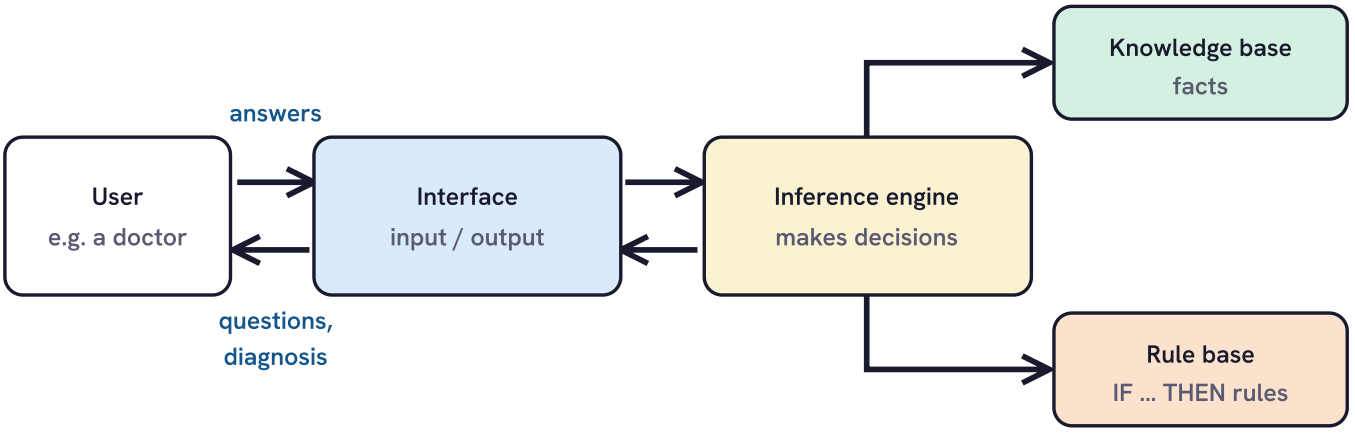
Characteristic	What it means	Example
Collection of data and **the rules for using that data**	it holds facts and rules that say what to do with them	a medical system stores symptoms and IF … THEN rules
Ability to reason	it can work out a conclusion or **make a decision** from the data	decides the most likely illness
Ability to learn and adapt (can be included)	it can **change its own processes / data** from experience, so it improves	a game character learns how a player moves

The syllabus covers two kinds of AI system: **expert systems** and **machine learning**.

4 Expert systems

An **expert system** copies the knowledge of a human expert (a doctor, a mechanic, a geologist) so that someone else can get an expert answer: a **diagnosis**, a fault, a decision. It has four components:

Component	Its job
Knowledge base	a database of **facts** about the subject (collected from experts)
Rule base	the **rules** (IF … THEN) for using the facts; **links the facts** in the knowledge base so the inference engine can use them
Inference engine	the part that **makes decisions**: it **applies the rule base to the knowledge base** and the user's answers to reach a **diagnosis**; it also **decides which question to ask next** based on the previous answers
Interface	how the user **inputs data** (answers questions) and **sees the output** (the questions and the diagnosis)



The four components of an expert system.

GENERAL METHOD **How an expert system works (e.g. diagnosing a car fault)**

1. The user enters data through the **interface** (or plugs the car into it), e.g. "the brakes squeak".
2. The **inference engine** **compares the data with the knowledge base** ...
3. ... and **applies the rule base** to the knowledge base.
4. It **decides which question to ask next**, **based on the previous answers**, and shows it on the interface.
5. When it has enough data it **decides the diagnosis** (the most likely one if there are several).
6. The **interface outputs the diagnosis** (often with how it was reached).

✗ COMMON MISTAKE

The **inference engine** makes the decisions. The knowledge base only stores facts and the rule base only stores rules: neither of them "decides".

5 Machine learning

Machine learning: a program that can **automatically adapt its own processes and/or data**, so it improves without being reprogrammed by a person.

GENERAL METHOD **How a system uses machine learning (any scenario)**

1. It **collects / gathers data** as it works (e.g. where obstacles are, how a user speaks, which results were clicked).
2. It **analyses the data to find patterns**.
3. It **stores successful and unsuccessful** results / actions.
4. It **adapts its own processes, rules or data** using this.
5. So **next time** it makes **fewer mistakes** / gives **more accurate** results (say what improves in the scenario).

Scenario	What it learns	So …
robot vacuum cleaner	the shape of the room, where obstacles and dirtier areas are	it takes the most efficient route
smart speaker	the user's voice, accent and different ways of asking	it understands voice commands better, ignores background noise
search engine	which results users clicked or ignored (feedback)	it changes its rules to give more relevant results
game character	patterns in the player's movements	it predicts and reacts to the player's next move
weather system	patterns in past weather data, feedback on its forecasts	it makes more accurate predictions

Training can be **supervised** (the system is given the inputs and the correct outputs) or **unsupervised** (it is given only inputs and must find the patterns itself). Either earns a mark when describing machine learning.

TRY IT YOURSELF

1. Which component of an expert system makes the decisions?
2. Which component stores the facts?
3. A program can automatically adapt its own processes and data. Name this ability.
4. Name the four components of an expert system.

6 Summary

- AI: the simulation of intelligent behaviours by computers.
- Characteristics: data + rules for using it; ability to reason; can learn and adapt.
- Expert system: knowledge base (facts) · rule base (rules) · inference engine (applies rules to facts, decides next question and diagnosis) · interface.
- Machine learning: automatically adapts its own processes / data: gathers data → patterns → stores results → adapts → fewer mistakes.

IF YOU SEE …

"explain how an expert system operates" [5-6]	→ interface input · inference engine · knowledge base · rule base · applies rules to facts · decides next question · outputs diagnosis
"explain how X can make use of machine learning" [3-4]	→ gathers data · patterns · adapts own processes · so … (scenario) · fewer mistakes

PART 2

How it is examined

Question types, what the examiner gives marks for, and real past-paper questions solved.

7 Ways they test it

TYPE 1 Define / characteristics

> *"Describe what is meant by AI" [2-3]; "identify three other characteristics of AI" [3]*

Spot it "what is meant by".

1. simulation of intelligent behaviour · data + rules · reason · learn / adapt

TYPE 2 Components

> *"Identify the three other components in an expert system" [3]; "circle three components" [3]*

Spot it one component already named.

1. From knowledge base, rule base, inference engine, interface: leave out the one given.

TYPE 3 Operation

> *"Explain how the expert system operates and how it is used to diagnose the problem" [5-6]*

Spot it "operate / diagnose".

1. Follow the method; say "inference engine" for every decision.

TYPE 4 Cloze

> *"Complete the paragraph using terms from the list" [5-7]*

Spot it a word list.

1. Facts → knowledge base; decides → inference engine; links / applies → rule base; types / output → interface.

TYPE 5 **Machine learning in a scenario**

> *"Explain how the robot vacuum cleaner can make use of machine learning" [3-4]*

Spot it a named device.

1. Method + what it learns in that device.

8 What the examiner looks for

"Explain how an expert system operates" [6]

Marking points (one mark each, up to the marks shown)

- It has an interface ...
- ... used to input data / view output
- It has a knowledge base
- It has a rule base
- It has an inference engine
- Applies the rule base to the knowledge base to provide the output / diagnosis
- Decides what to ask next based on the data input

KEYWORDS **interface** **knowledge base** **rule base** **inference engine** **applies** **diagnosis**

TOO VAGUE "the knowledge base decides"; "it thinks like a human"

9 Past-paper questions, solved

0478/12/M/J/24 Q10 ↗ Paper 1 · Computer systems **7 marks** ⤢ Full size

10 A garage uses an expert system to help diagnose any problems with cars that need repair.

(a) The expert system is an example of artificial intelligence (AI).

Describe what is meant by AI.

.....

.....

.....

..... [2]

(b) A car has a problem with its braking system, so it is brought into the garage.

Explain how the expert system operates and how it is used to help diagnose the problem.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

Swipe sideways to read the whole question

How to start (a) two characteristics [2]. (b) the operation method, in the garage's words [5].

▼ **Show a full-mark answer and the mark scheme** · official marking

WHAT TO WRITE

(a) The simulation of intelligent behaviours by computers. It has the ability to reason.

(b) The mechanic enters data about the brakes into the interface. The inference engine decides which questions to ask, using the previous answers given. It compares the answers entered with the knowledge base and the rule base. It decides on the most likely diagnosis and the interface outputs it.

PART	ANSWER / WORKING	MARKS	GUIDANCE
10(a)	Any two: simulation of intelligent behaviour · data + rules for using it · ability to reason · ability to learn / adapt	B2	
10(b)	Any five: data entered via interface · inference engine decides which questions · … using previous answers · decides diagnosis · … comparing with knowledge base and rule base · most likely option · interface outputs diagnosis · explanation system	B5	

Total: 7 marks

10 A car repair garage uses an expert system.

(a) Complete the description about the operation of the expert system.

Use the terms from the list. Some of the terms in the list will **not** be used.

inference engine interface knowledge base

machine learning mechanical engine output device

question base rule base

An expert system has a ..... that contains a list of facts. The ..... applies the ..... to the ..... to reach a diagnosis for the repair of the car. The user provides data to the system using an ..... . [5]

(b) The expert system has machine learning capabilities.

Describe what is meant by machine learning capabilities.

.....

.....

.....

.....

.....

.....

.....

..... [4]

Swipe sideways to read the whole question

How to start (a) five gaps: match each gap to a component's job. (b) four points about machine learning.

▼ **Show a full-mark answer and the mark scheme** · official marking

WHAT TO WRITE

(a) An expert system has a **knowledge base** that contains a list of facts. The **inference engine** applies the **rule base** to the **knowledge base** to reach a diagnosis for the repair of the car. The user provides data to the system using an **interface**.

(b) It is a form of AI that can adapt its own processes and edit its own data. It analyses patterns and stores successful and unsuccessful results, to influence future decisions. It can be trained, supervised or unsupervised.

PART	ANSWER / WORKING	MARKS	GUIDANCE
10(a)	knowledge base · inference engine · rule base // knowledge base · knowledge base // rule base · interface	**B5**	
10(b)	Any four: form of AI · adapts own processes · edits own data · can be trained · supervised / unsupervised · analyses patterns, stores results · to influence future decisions	**B4**	

Total: 9 marks

0478/12/O/N/24 Q8 ↗ Paper 1 · Computer systems **6 marks** ⤢ Full size

8 A robot vacuum cleaner uses sensors to navigate around obstacles in a room.

(b) An expert system can be used to diagnose an error with a robot vacuum cleaner.

Circle **three** components that are part of an expert system.

knowledge base operating system firewall

server printer actuator inference engine

rule base encryption

[3]

(c) Explain how the robot vacuum cleaner can make use of machine learning.

..... [3]

Swipe sideways to read the whole question

How to start (b) circle exactly three. (c) machine learning **in this device** : say what it learns.

▼ Show a full-mark answer and the mark scheme · official marking

WHAT TO WRITE

(b) Knowledge base, rule base, inference engine.

(c) It gathers data while vacuuming, such as where obstacles are and where the dirtier areas are. It adapts its own processes using this data, so it knows the most efficient route to vacuum the room and which areas to concentrate on.

PART	ANSWER / WORKING	MARKS	GUIDANCE
8(b)	knowledge base · rule base · inference engine	B3	
8(c)	Any three: gathers data · adapts own processes · … obstacles · dirtier areas · path / shape of room · most efficient route · areas to avoid	B3	

Total: 6 marks

6 A search engine uses artificial intelligence (AI) to identify the most relevant web pages for the user.

(a) One characteristic of AI is the ability to learn.

Identify **three** other characteristics of AI.

1 .....

.....

2 .....

.....

3 .....

.....

[3]

(b) The search engine uses machine learning.

Explain how machine learning is used by the search engine.

.....

.....

.....

.....

.....

..... [3]

Swipe sideways to read the whole question

How to start (a) the question gives "learn": give three other characteristics. (b) how the search engine changes from feedback.

▼ **Show a full-mark answer and the mark scheme** · official marking

WHAT TO WRITE

(a) The collection of data; rules for using the data; the ability to reason.

(b) If a result does not give a suitable response, this is recorded. The search engine changes its own data and rules according to this feedback, so next time it provides more relevant results.

PART	ANSWER / WORKING	MARKS	GUIDANCE
6(a)	Any three: collection of data · rules for data · ability to reason · ability to adapt	B3	
6(b)	Any three: changes its data / rules · according to feedback · unsuitable result recorded · result changed next time · more accurate / relevant	B3	

Total: 6 marks

0478/13/O/N/24 Q5 ↗ Paper 1 · Computer systems — **4 marks** — ⤢ Full size

5 A farmer has a plough that is an automated system. The plough is used to dig the ground in a field to prepare it for planting seeds.

The plough uses sensors and a microprocessor to maintain a straight line when digging the ground.

(d) The plough uses artificial intelligence (AI) to navigate its way around the field.

Explain how the plough makes use of AI for this purpose.

..... [4]

Swipe sideways to read the whole question

How to start Four marks: name machine learning, then what it gathers and what improves.

▼ **Show a full-mark answer and the mark scheme** · official marking

WHAT TO WRITE

It could use machine learning. It gathers data while ploughing, such as the dimensions of the field and where obstacles are, and uses this data to adapt its own process, creating a map of the field and the most efficient route, so it makes fewer mistakes in future.

PART	ANSWER / WORKING	MARKS	GUIDANCE
5(d)	Any four: machine learning · gathers data from ploughing · adapts own process · fewer mistakes · … dimensions / landscape / obstacles · map of field · most efficient route · knows what to avoid	B4	

Total: 4 marks

10 Common mistakes

✗ "The knowledge base makes the diagnosis"

✓ "The inference engine applies the rule base to the knowledge base to make the diagnosis"

✗ "AI is a robot"

✓ "AI is the simulation of intelligent behaviour by computers"

Robots and AI are separate topics.

✗ "Machine learning means it learns"

✓ "It automatically adapts its own processes and data"

Don't define a word with itself.

✗ Generic machine-learning answers

✓ Say what this device learns (route, voice, obstacles...)

Scenario marks need the scenario.

11 Practice

Practice: easy, medium, hard

1. Name the component of an expert system that stores facts.
2. Give two characteristics of AI. [2]
1. Describe the role of the rule base in an expert system. [2]
2. Describe the role of the inference engine. [2]
1. A chess program uses machine learning. Explain how this helps it play better. [4]

12 Can I do this?

0 / 3 ticked

- [ ] I can define AI and give its characteristics.
- [ ] I can name the four components of an expert system and explain how it reaches a diagnosis.
- [ ] I can explain machine learning in a given scenario.

Anything unticked: revise that section first (each line links to it). All ticked: take the quiz.

Answers

Answers to the "Try it yourself" and practice questions on this page. Try every question first.

Try it yourself 1

1.

ANSWER The inference engine

2.

ANSWER The knowledge base

3.

ANSWER Machine learning

4.

ANSWER Knowledge base, rule base, inference engine, interface

Practice: easy, medium, hard

Easy 1.

ANSWER Knowledge base

Easy 2.

ANSWER

e.g. collection of data and rules for using it · ability to reason · ability to learn / adapt

Medium 1.

ANSWER

Stores the rules (IF ... THEN) · used by the inference engine · to link the facts in the knowledge base

Medium 2.

ANSWER

Makes decisions · by applying the rules to the facts / knowledge · to give a result / diagnosis

Hard 1.

ANSWER

Collects data about each game / the opponent's moves · finds patterns · stores successful and unsuccessful moves · adapts its own processes · so it chooses better moves and makes fewer mistakes next time