

Week 16

# IGCSE Computer Science

Homework bundle for this week

本周作业合集

exercises.lol

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## 6. Automated and emerging technologies

Starter Quiz · 课前小测

IGCSE Computer Science

Name: \_\_\_\_\_ Score: \_\_\_\_\_

1. An automated system is one that:
  - ☐ senses and responds to its environment with no human intervention
  - ☐ needs a person to make every decision
  - ☐ has no sensors
  - ☐ cannot take any action
2. Which is a defining characteristic of a robot?
  - ☐ it follows programmable instructions that can be changed
  - ☐ it can never be reprogrammed
  - ☐ it has no moving parts
  - ☐ it thinks for itself
3. Artificial intelligence is:
  - ☐ the simulation of human intelligence by computer systems
  - ☐ any program at all
  - ☐ a type of hardware
  - ☐ a network protocol
4. In an automated system, the microprocessor:
  - ☐ compares sensor data with stored values and makes decisions
  - ☐ measures temperature
  - ☐ opens a window
  - ☐ displays the data
5. Which is a typical use of a robot?
  - ☐ welding car parts on a production line
  - ☐ deciding company strategy
  - ☐ writing a novel from scratch
  - ☐ making moral judgements
6. Automated systems can work 24/7 consistently and safely in dangerous places, but they cost more to set up and cope badly with unexpected situations.
  - ☐ True    ☐ False

7. A robot uses sensors to gather data and actuators (such as motors) to act on its surroundings.
- ☐ True    ☐ False
8. All AI in use today is narrow AI (good at one specific task); strong AI, with human-like self-awareness, does not yet exist.
- ☐ True    ☐ False
9. Which is a characteristic of an AI system?
- ☐ it can learn from data and adapt its behaviour
- ☐ it never changes
- ☐ it cannot use rules
- ☐ it stores no data
10. An advantage of using robots is that they:
- ☐ do dull or dangerous jobs quickly and accurately, without tiring
- ☐ are always cheap
- ☐ can react to any new situation
- ☐ never need maintenance

## 6. Automated and emerging technologies

Answers · 答案

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IGCSE Computer Science

### 1. senses and responds to its environment with no human intervention

Automated systems work on their own, sensing data and acting on it.

### 2. it follows programmable instructions that can be changed

A robot has a physical body, electronics, and a changeable program — it can be reprogrammed for a new job.

### 3. the simulation of human intelligence by computer systems

AI is a computer doing tasks that normally need human thinking.

### 4. compares sensor data with stored values and makes decisions

The microprocessor decides; the sensor measures and the actuator acts.

### 5. welding car parts on a production line

Robots excel at repetitive physical tasks like welding or vacuuming; they don't make independent judgements.

### 6. True

Consistency and safety are the strengths; setup cost and inflexibility (no judgement for the unexpected) are the trade-offs.

### 7. True

Sense, process, then act.

### 8. True

A chess engine or a recommender is narrow AI; a self-aware, general mind (strong AI) remains theoretical.

### 9. it can learn from data and adapt its behaviour

AI collects data + rules, reasons, draws conclusions, learns and adapts.

### 10. do dull or dangerous jobs quickly and accurately, without tiring

Robots are fast, accurate and tireless on dull/dangerous tasks, though they are costly and inflexible.

## 6.1 Automated systems

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

Total: 27 marks

**KEY WORDS** sensor 传感器 • microprocessor 微处理器 • automated system 自动化系统  
 • actuator 执行器 • a rogue value 哨兵值

### Objective

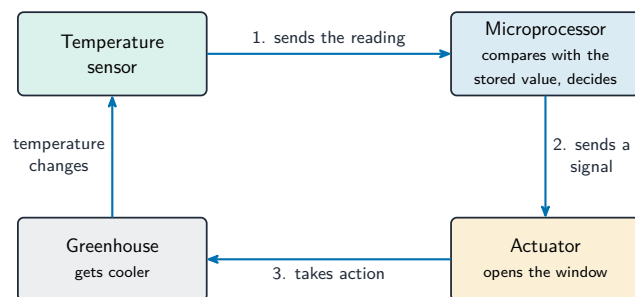
Build the skills to answer exam questions on **automated systems** 自动化系统 — the roles of **sensors** 传感器, **microprocessors** 微处理器 and **actuators** 执行器, and the pros and cons.

**You must be able to:**

- describe the role of the sensor, microprocessor and actuator
- describe the control loop
- give advantages and disadvantages of automated systems

### 1 Worked examples

#### ■ The control loop



*Sensor reads data → microprocessor compares with stored values → signals actuator → the loop repeats*

- **sensor:** measures a quantity; **microprocessor:** decides; **actuator:** causes action.

#### ■ Algorithms: what each one is for

**Pseudocode or flowchart?** Both describe the same algorithm. Pseudocode is quicker to write and translates straight into code; a flowchart shows the flow of control visually and is easier to follow at a glance.

**The standard methods the exam expects:**

- **totalling** 求和:  $Total \leftarrow Total + Value$  inside the loop, with  $Total \leftarrow 0$  before it.
- **counting** 计数:  $Count \leftarrow Count + 1$  each time a condition is met.
- **finding the largest:** set **Largest** to the first value (or a very small number), then replace it whenever a bigger value appears.
- **finding the smallest:** the same with the comparison reversed.
- **calculating an average:** total divided by the count, after the loop.
- **a rogue value** 哨兵值: a value outside the possible data that stops the loop, such as  $-1$  for a mark out of 100. Test for it before adding, or the rogue value joins the total.

**Worked example.** Input marks until  $-1$  is entered, then output the total and the average.

```

Total ← 0
Count ← 0
INPUT Mark
WHILE Mark <> -1 DO
    Total ← Total + Mark
    Count ← Count + 1
    INPUT Mark
ENDWHILE
IF Count > 0 THEN
    OUTPUT "Total ", Total
    OUTPUT "Average ", Total / Count
ELSE
    OUTPUT "No marks entered"
ENDIF
  
```

Two details earn marks: the first **INPUT** **before** the loop so the condition can be tested, and the check that **Count** is not zero before dividing.

**Trace tables.** Draw one column per variable and one per output, then work through the algorithm one line at a time, writing each new value on a new row. Never rub out an old value: the examiner wants to see the sequence.

## 2 Practice

2.1 State the role of a sensor in an automated system. [1]

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2.2 State the role of an actuator. [1]

---

2.3 State what a rogue value is and give one example. [2]

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2.4 Give the line of pseudocode that adds **Mark** to a running total. [1]

---

2.5 Explain why the total must be set to zero before the loop begins. [2]

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## 3 Exam-style questions

3.1 In an automated greenhouse, the part that decides whether to open a window is the: [1]

- A sensor
- B microprocessor
- C actuator
- D window

---

3.2 A greenhouse is too hot.

(a) Describe the steps the system takes to cool it. [3]

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(b) State one disadvantage of automated systems. [1]

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3.3 A program inputs the temperatures recorded each day until the rogue value  $-99$  is entered.

(a) State why  $-99$  is a suitable rogue value here. [1]

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(b) Write pseudocode that inputs the temperatures, and outputs the total, the average and the highest temperature. [7]

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(c) Explain why the program must check the count before calculating the average. [2]

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[4]

[1]

**2.1** it measures a physical quantity and sends the data.

**2.3** A value outside the range of the real data, used to stop a loop; for example  $-1$  for a mark out of 100.

**2.5** The variable would otherwise start with whatever value was left in it, so the total would be wrong from the first addition.

**3.2** (a) the temperature sensor sends the reading to the microprocessor; the microprocessor compares it with the stored value; it signals an actuator to open a window.

**3.3 (a)** A temperature of  $-99\text{ }^{\circ}\text{C}$  never occurs in the real data, so it cannot be confused with a genuine reading.

(c) If no temperatures were entered the count is zero, and dividing by zero would make the program crash.

(e) The flow of control, especially the branches and the loop, can be seen at a glance.

- 1 A flower shop has a room that has an air-conditioning system. It is used to keep the room at a constant temperature for storing flowers.

The owner uses a keypad to set the temperature for the room.

- (a) Tick (✓) **one** box to show whether a keypad is an example of an input, output, process or storage device.

- |          |         |                          |
|----------|---------|--------------------------|
| <b>A</b> | input   | <input type="checkbox"/> |
| <b>B</b> | output  | <input type="checkbox"/> |
| <b>C</b> | process | <input type="checkbox"/> |
| <b>D</b> | storage | <input type="checkbox"/> |

[1]

- (b) The owner of the shop enters a denary number to set the temperature for the room.

The denary number is converted to a binary number to be processed. The binary number is stored in a register in the air conditioning system.

- (i) Give the binary number that would be stored when the denary number 24 is entered.

..... [1]

- (ii) Give the binary number that would be stored when the denary number 101 is entered.

..... [1]

- (iii) The binary number 00010011 is stored in the register.

Give the denary number that has been entered for this binary number to be stored.

..... [1]

- (iv) The binary number 00100010 is stored in the register.

Give the denary number that has been entered for this binary number to be stored.

..... [1]

Working space

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 .....  
 .....  
 .....  
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 .....

- (c) If the air-conditioning system detects an error, it displays an error code. The error code is displayed as a hexadecimal number. The binary number for each error code is stored in a register.

- (i) Give the binary number that is stored in the register to display the error code 51.

..... [1]

- (ii) Give the binary number that is stored in the register to display the error code E3.

..... [1]

- (iii) Give the hexadecimal number that is displayed when the binary number 10000010 is stored in the register.

..... [1]

- (d) If the owner of the shop wants to make the room very cold, she may need to enter a negative denary number.

The negative denary number could be represented using two's complement.

Give the two's complement 8-bit binary integer that would be stored for the temperature -5.

Show all your working.

Working space .....

.....  
 .....  
 .....

Two's complement 8-bit binary integer .....

[2]

(e) The air-conditioning system uses a temperature sensor and a microprocessor to keep the temperature of the room at a constant level.

(i) Tick (✓) **one** box to show whether the sensor is an example of an input, output, process or storage device.

- |                  |                          |
|------------------|--------------------------|
| <b>A</b> input   | <input type="checkbox"/> |
| <b>B</b> output  | <input type="checkbox"/> |
| <b>C</b> process | <input type="checkbox"/> |
| <b>D</b> storage | <input type="checkbox"/> |

[1]

(ii) The temperature sensor continuously sends analogue data to the microprocessor. This data is then converted to digital.

Explain how the microprocessor keeps the temperature of the room at a constant level.

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..... [3]

(f) The air-conditioning system is an example of an embedded system.

Explain why the air-conditioning system is an embedded system.

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..... [2]

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]

(ii) The data for the alert is sent using serial simplex data transmission.

Explain how the data is sent using serial simplex data transmission.

.....

.....

.....

.....

.....

.....

..... [3]

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

1 .....

.....

2 .....

.....

[2]

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

.....

..... [1]

- (f) The automated weather system is upgraded and given machine learning capabilities.

- (i) Machine learning is part of a branch of computer science.

Identify the name of this branch of computer science.

..... [1]

- (ii) Explain how the machine learning capabilities can be used to predict future weather.

.....

.....

.....

.....

.....

..... [3]

- 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.

1 .....

.....

2 .....

.....

[2]

- (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.

.....

.....

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.....

.....

..... [4]

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.

551

- (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]

- (d)** The self-driving tractor has an in-built expert system that the farmer can use to solve any errors with the tractor.

Identify **three** components of an expert system.

1 .....

[3]

- (e) At the end of each day the self-driving tractor transmits the data it has collected to the farmer's computer in their house.

The transmission uses an echo check.

- (i) Describe the role of the self-driving tractor and the farmer's computer in the echo check.

.....

[3]

[3]

(ii) Another method of error checking is a parity block check.

The table shows 7 bytes that are transmitted using odd parity. The parity bit has been completed for each byte.

Complete the parity byte for the data.

|             | parity bit | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 |
|-------------|------------|-------|-------|-------|-------|-------|-------|-------|
| byte 1      | 1          | 1     | 0     | 0     | 1     | 1     | 1     | 0     |
| byte 2      | 1          | 0     | 0     | 0     | 0     | 1     | 1     | 0     |
| byte 3      | 0          | 1     | 0     | 0     | 0     | 0     | 0     | 0     |
| byte 4      | 0          | 1     | 0     | 0     | 1     | 1     | 1     | 1     |
| byte 5      | 1          | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| byte 6      | 0          | 1     | 1     | 1     | 1     | 1     | 1     | 1     |
| byte 7      | 1          | 1     | 0     | 0     | 1     | 1     | 0     | 1     |
| parity byte |            |       |       |       |       |       |       |       |

[3]

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]

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- 5 A farm has an automated drinking system for its animals. The drinking system has a water bowl that contains the water. When the water bowl is empty, it is automatically refilled.

The system uses a sensor and a microprocessor.

- (a)** Identify the most appropriate sensor for this system.

..... [1]

- (b) Describe how the sensor and the microprocessor are used to automatically refill the water bowl.

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..... [6]

## 6.2 Robotics

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

**Total: 25 marks**

**KEY WORDS** robots 机器人 • robotics 机器人技术 • mechanical 机械的  
• electrical components 电子元件 • flowchart 流程图

## Objective

Build the skills to answer exam questions on **robotics** 机器人技术 — the characteristics of a robot, what robots do, and their limitations.

You must be able to:

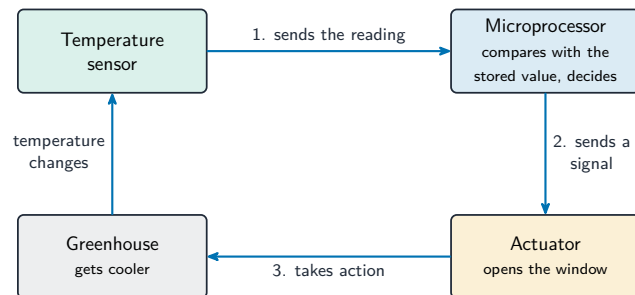
- give the characteristics of a robot
- give examples of robot roles
- discuss advantages and the key limitation (no independent decisions)

## 1 Worked examples

- Robots



*A robot has a physical structure, electrical components, and programmable instructions*



*A robot senses, processes and acts in a control loop*

- **roles:** factory equipment (welding, moving parts), domestic (robot vacuum).
- **key limit:** a robot cannot think for itself — it only does what it is programmed to do.

#### ■ Reading a flowchart, and the difference between the three system types

A **flowchart** 流程图 uses a fixed set of shapes: an oval for start and stop, a parallelogram for input and output, a rectangle for a process, and a diamond for a decision with a labelled Yes and No branch. Every path must reach a stop.

**Automated, monitoring, control.** A **monitoring** system reads sensors and only reports or warns; a **control** system reads sensors and acts to change what is happening; an **automated** system combines both to run a whole task without a person. The exam wants the loop named in order: sensor sends readings continuously, ADC converts them, the microprocessor compares each with a stored value, and it acts or does not act, then the cycle repeats.

**Worked example (a heating system).** Describe the process. The temperature sensor sends readings continuously; the ADC converts each to digital; the microprocessor compares the reading with the stored value; if the reading is below it, the microprocessor sends a signal to switch the heater on; if it is above, it switches the heater off; the process repeats. Because the microprocessor acts on the reading, this is a control system, not merely monitoring.

**Where each is used.** Monitoring: a patient's heart rate in a hospital, a burglar alarm, pollution measurement. Control: central heating, a greenhouse, traffic lights, a chemical process. Automated: a robotic production line, a self-driving vehicle.

## 2 Practice

2.1 State two characteristics of a robot. [2]

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2.2 Give one example of a robot used in the home. [1]

---

2.3 Identify the flowchart shape used for a decision, and for an input. [2]

---



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2.4 Explain the difference between a monitoring system and a control system. [2]

---



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2.5 Give one example each of a monitoring system and a control system. [2]

---



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## 3 Exam-style questions

3.1 A key limitation of a robot is that it: [1]

- A never breaks down
- B cannot make independent decisions
- C works for free
- D gets tired

---

**3.2** A factory uses robot arms on a production line.

(a) State two advantages of using robots here.

[2]

---

---

(b) State one disadvantage of using robots.

[1]

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**3.3** A chemical process must be kept between 30 °C and 35 °C. A microprocessor reads a temperature sensor and switches a cooler on and off.

(a) Describe how the microprocessor uses the sensor readings to keep the temperature in range.

[5]

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(b) Explain why this is a control system and not a monitoring system.

[2]

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---

(c) State the purpose of the analogue-to-digital converter in this system.

[1]

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(d) The process must also raise an alarm if the temperature goes above 40 °C. Describe the extra comparison the microprocessor makes, and the shape a flowchart would use for it.

[2]

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---

(e) Give two advantages of using a microprocessor rather than a person to control this process.

[2]

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## Solutions

**2.1** any two of: a physical (mechanical) structure; electrical components; programmable instructions.

**2.2** a robotic vacuum cleaner.

**2.3** A diamond for a decision; a parallelogram for an input.

**2.4** A monitoring system only reads and reports the data, or gives a warning; a control system also sends signals that change the process.

**2.5** Monitoring: a patient's heart rate in hospital, a burglar alarm, or pollution measurement. Control: central heating, a greenhouse, traffic lights, or an automatic door.

**3.1 B.** A robot cannot make independent decisions.

**3.2** (a) any two of: do dull/dangerous jobs; work quickly and accurately; do not tire/bore.  
(b) any of: expensive to buy/maintain; can replace human workers; cannot make its own decisions.

**3.3** (a) The temperature sensor sends readings continuously; the ADC converts each reading to digital; the microprocessor compares the reading with the stored values of 30 °C and 35 °C; if the reading is above 35 °C it sends a signal to switch the cooler on, and if it falls below 30 °C it switches the cooler off; the process repeats continuously.

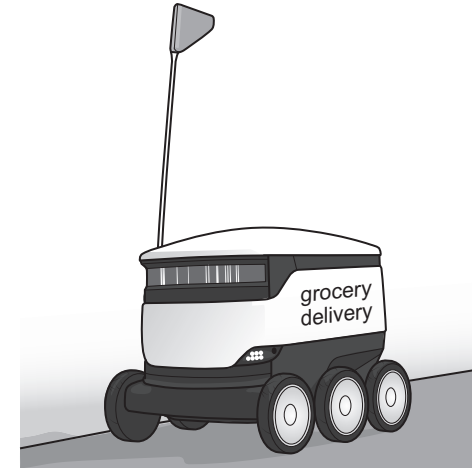
(b) The microprocessor does not only record the readings: it sends signals that switch the cooler and so change the temperature itself, which is what makes it a control system.

(c) It converts the sensor's analogue signal into digital values the microprocessor can process.

(d) The microprocessor also compares each reading with the stored value of 40 °C and, if the reading is greater, sends a signal to sound the alarm; a flowchart would show this as a decision, drawn as a diamond with Yes and No branches.

(e) Any two of: it reacts far faster than a person; it never gets tired or distracted, so it works continuously; it is more accurate and consistent; it can work in conditions unsafe for people.

**5** A supermarket wants to start delivering groceries to local elderly people, using robots.



**(a)** Describe the characteristics of a robot.

.....

.....

.....

.....

.....

..... [3]

**(b)** Explain **one** benefit to the supermarket of using robots to deliver groceries to elderly customers.

.....

.....

.....

..... [2]

**(c)** Explain **one** drawback to the elderly customers of robots being used to deliver their groceries.

.....

.....

.....

..... [2]

**(d)** Each robot has a media access control (MAC) address.

Tick (✓) **one** box to show the correct statement about a MAC address.

- A** It is assigned by the manufacturer. ☐
- B** It is assigned by the product. ☐
- C** It is assigned by the router. ☐
- D** It is assigned by the user. ☐

[1]

**(e)** The robots have artificial intelligence (AI).

Give **three** ways the robots could make use of AI.

- 1 .....
- 2 .....
- 3 .....

[3]

**8** A robot is used to move car parts in a factory.

**(a)** One characteristic of the robot is that it has a mechanical structure.

Give **one** other characteristic of a robot.

.....

..... [1]

**(b)** The robot has firmware.

State what is meant by firmware.

.....

..... [1]

**(c)** Interrupts are generated when the robot is operating in the factory.

Give **two** examples of interrupts that may be generated when the robot is in operation.

- 1 .....
- 2 ..... [2]

**(d)** Give **two** advantages to the workers in the factory of using robots to move the car parts.

- 1 .....
- 2 ..... [2]

**(e)** The robots have the ability to automatically adapt their own processes.

State the name of the ability described.

..... [1]

**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.

1 .....  
 .....  
 2 .....  
 .....  
 3 .....  
 ..... [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.

1 .....  
 .....  
 .....  
 2 .....  
 .....  
 ..... [2]

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

1 .....  
 .....  
 .....  
 2 .....  
 .....  
 ..... [2]

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

Explain how this will improve the robot.

.....  
 .....  
 .....  
 ..... [2]

- 9 A company uses robots in its factory to manufacture large pieces of furniture.
- (a) One characteristic of a robot is that it is programmable.
- State **two** other characteristics of a robot.
- 1 .....
- 2 .....
- [2]
- (b) Give **two** advantages to company employees of using robots to manufacture large pieces of furniture.
- 1 .....
- 2 .....
- [2]
- (c) Give **one** disadvantage to the company's owners of using robots to manufacture large pieces of furniture.
- .....
- [1]

- 6 A company is involved in robotics.
- One of its robots is designed to make a specific movement depending on a binary value.
- (a) The table gives some of the movements for the robot.
- Complete the table by writing the missing binary, denary or hexadecimal value for each movement.
- | Movement       | Binary   | Denary | Hexadecimal |
|----------------|----------|--------|-------------|
| forward 1 step | 00011111 | 31     |             |
| back 1 step    |          | 140    | 8C          |
| turn right     | 01011010 |        | 5A          |
| turn left      |          | 120    | 78          |
- [4]
- Working space
- .....
- .....
- .....
- .....
- .....
- .....
- .....
- (b) Describe what is meant by robotics.
- .....
- .....
- .....
- .....
- [2]

- (c) The robot has a sensor and a microprocessor.

The robot will move forward continuously until it detects an object that is less than or equal to 10cm in front of it.

If an object is less than or equal to 10 cm in front of it, the robot turns 90 degrees right. It then tries to move forward again.

Explain how the sensor and the microprocessor are used to automate this robot.

..... [7]

- (d) The robot needs to find its way through different puzzles. Each puzzle has a series of paths that the robot needs to follow to find its way to the end of the puzzle. The puzzle contains dead ends and obstacles, so the robot needs to decide which way to go.

The robot's program will use artificial intelligence (AI).

- (i) Describe the characteristics of Al.

[3]

- (ii) Explain how the program will use AI.

[4]

# 6.3 Artificial intelligence

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_ Total: 25 marks

**KEY WORDS** artificial intelligence 人工智能 • learn 学习 • adapt 适应 • narrow ai 弱人工智能  
• general ai 通用人工智能

## Objective

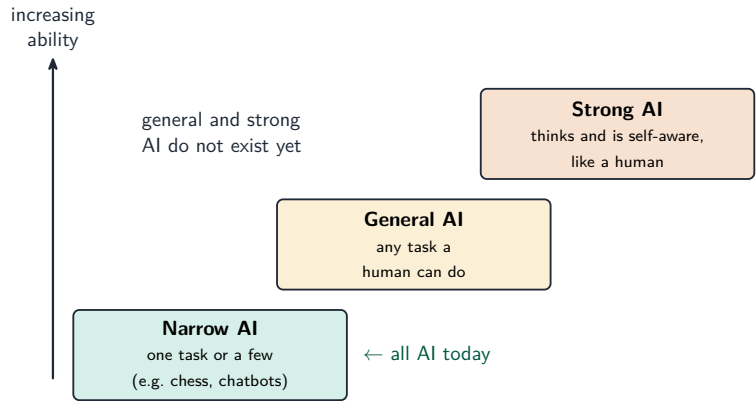
Build the skills to answer exam questions on **artificial intelligence** 人工智能 — what AI is, its characteristics, examples, and **narrow/general/strong AI** 弱/通用/强人工智能.

You must be able to:

- define AI and give its characteristics
- give examples of AI (expert systems, NLP, self-driving cars)
- distinguish narrow, general and strong AI

## 1 Worked examples

### ■ Levels of AI



*Narrow AI: one task (all AI today). General AI: any human task. Strong AI: self-aware (does not exist yet)*

- **AI:** the simulation of human intelligence by computers.
- **characteristics:** collect data + rules; reason; draw conclusions; learn; adapt.

### ■ Logic gates, expressions and truth tables

Six gates, with their symbols in words and their rule:

| Gate | Output is 1 when                | Expression             |
|------|---------------------------------|------------------------|
| NOT  | the input is 0                  | $\overline{A}$         |
| AND  | <b>both</b> inputs are 1        | $A \cdot B$            |
| OR   | <b>at least one</b> input is 1  | $A + B$                |
| NAND | <b>not both</b> are 1           | $\overline{A \cdot B}$ |
| NOR  | <b>neither</b> input is 1       | $\overline{A + B}$     |
| XOR  | the inputs are <b>different</b> | $A \oplus B$           |

**Building a truth table.** With  $n$  inputs there are  $2^n$  rows. Write the input columns in binary counting order, then add one working column per gate, in the order the signals flow, before the final output column. Working columns earn marks even if the last column is wrong.

**Worked example.** Complete a truth table for  $X = (A \cdot B) + \overline{C}$ .

| A | B | C | $A \cdot B$ | $\overline{C}$ | X |
|---|---|---|-------------|----------------|---|
| 0 | 0 | 0 | 0           | 1              | 1 |
| 0 | 0 | 1 | 0           | 0              | 0 |
| 0 | 1 | 0 | 0           | 1              | 1 |
| 0 | 1 | 1 | 0           | 0              | 0 |
| 1 | 0 | 0 | 0           | 1              | 1 |
| 1 | 0 | 1 | 0           | 0              | 0 |
| 1 | 1 | 0 | 1           | 1              | 1 |
| 1 | 1 | 1 | 1           | 0              | 1 |

**Turning a problem into a circuit.** Read the sentence for the joining words. “The alarm sounds when the door is open **and** the system is armed” is AND. “...when the door **or** the window is open” is OR. “...when the system is **not** armed” is NOT. Write the expression first, then draw one gate per operator, feeding the outputs forward.

## 2 Practice

2.1 Define artificial intelligence. [1]

2.2 Give one example of an AI application. [1]

**2.3** Give the logic expression for each: the output is 1 only when both inputs are 1; the output is 1 when the inputs are different. [2]

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**2.4** State how many rows a truth table needs for four inputs, and explain why. [2]

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**2.5** Identify the gate whose output is 1 unless both inputs are 1. [1]

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**3 Exam-style questions**

**3.1** A chess-playing program that can do only that one task is an example of: [1]

- **A** narrow AI
- **B** general AI
- **C** strong AI
- **D** an automated system

---

**3.2** AI systems have several characteristics.

(a) State two characteristics of an AI system. [2]

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(b) State the difference between narrow AI and general AI. [2]

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**3.3** A greenhouse system sounds an alarm. The alarm sounds when the temperature is too high **and** the window is closed, **or** when the water level is low.

Let  $T = 1$  mean the temperature is too high,  $W = 1$  mean the window is open, and  $L = 1$  mean the water level is low.

(a) Write the logic expression for the alarm output  $X$ . [3]

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---

(b) Complete the truth table for your expression. [4]

| T | W | L | $\overline{W}$ | $T \cdot \overline{W}$ | X |
|---|---|---|----------------|------------------------|---|
| 0 | 0 | 0 |                |                        |   |
| 0 | 0 | 1 |                |                        |   |
| 0 | 1 | 0 |                |                        |   |
| 0 | 1 | 1 |                |                        |   |
| 1 | 0 | 0 |                |                        |   |
| 1 | 0 | 1 |                |                        |   |
| 1 | 1 | 0 |                |                        |   |
| 1 | 1 | 1 |                |                        |   |

---

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(c) Explain, using a row of your table, what happens when the temperature is too high and the window is open. [2]

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(d) Identify the single gate that could replace  $\overline{T \cdot \overline{W}}$ , and state its rule. [2]

---

---

(e) A second system sounds only when the two sensors disagree. Name the gate needed and give its expression. [2]

---

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## Solutions

2.1 the simulation of human intelligence by computer systems.

2.2 any of: expert system; natural language processing; self-driving car.

2.3  $A \cdot B$  for AND;  $A \oplus B$  for XOR.

2.4 16 rows; each input has two possible values, so there are  $2^4 = 16$  combinations.

2.5 NAND.

3.1 A. A single-task program is narrow AI.

3.2 (a) any two of: collect data and rules; reason; draw conclusions; learn; adapt.

(b) narrow AI can do only one (or a few) tasks; general AI could do any task a human can do.

3.3 (a)  $X = (T \cdot \overline{W}) + L$ .

(b)  $\overline{W}$  column: 1, 1, 0, 0, 1, 1, 0, 0.  $T \cdot \overline{W}$  column: 0, 0, 0, 0, 1, 1, 0, 0. X column: 0, 1, 0, 1, 1, 1, 0, 1.

(c) The row  $T = 1$ ,  $W = 1$ ,  $L = 0$  gives  $X = 0$ ; the alarm does not sound, because an open window already lets the heat escape, so no action is needed.

(d) A NAND gate; its output is 1 unless both of its inputs are 1.

(e) XOR;  $X = T \oplus W$ .

Name:

IGCSE Computer Science: w25 12

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]

(b) Identify the input device that allows voice commands to be used as input.

..... [1]



- (c) The computer game is programmed using a high-level language.

Explain **one** difference between a high-level language and a low-level language.

.....

.....

.....

..... [2]

- (d) The programmer uses translators to translate the high-level language source code into machine code.

Identify the name of the translator that would be used for each of the statements. Each name may be used more than once.

- (i) Translates and executes the source code one line at a time.

..... [1]

- (ii) Translates the source code and will not execute it if errors are found. It instead produces a full report of the errors in the source code.

..... [1]

- (iii) Translates the source code and produces an executable file.

..... [1]

- (iv) Stops execution of the machine code where an error is found and will resume execution of the machine code once the error is fixed.

..... [1]

- 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]

9 A doctor's surgery has an expert system that helps diagnose the illnesses of its patients.

**(a)** Complete the paragraph about the operation of the expert system.

Use the terms from the list.

Some of the terms in the list will **not** be used. Some terms may be used more than once.

artificial      binary      central processing unit (CPU)      data

inference engine      interface      knowledge base      primary storage

|         |      |                        |           |
|---------|------|------------------------|-----------|
| process | real | read only memory (ROM) | rule base |
|---------|------|------------------------|-----------|

An expert system is a type of ..... intelligence. The doctor will type data about the symptoms of the illness into the .....

The ..... will decide which questions to ask the doctor.

It will do this by linking the facts in the ..... to the

The ..... will decide on a diagnosis and this will be output on the .....

[7]

**(b)** The expert system has the ability to automatically adapt its own processes and data.

Give the name of this ability.

..... [1]

**10** A business has a system that is described as having artificial intelligence (AI).

(a) State **one** of the main characteristics of an AI system.

[1]

**(b)** An AI system is an expert system.

Explain how an expert system operates.

[6]

9 One component of an expert system is the inference engine.

(a) Identify the **three** other components in an expert system.

1 .....

2 .....

3 .....

[3]

(b) Describe the role of the inference engine in an expert system.

.....

.....

.....

..... [2]