



CANDIDATE  
NAME

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CENTRE  
NUMBER

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## 0478/12

February/March 2023

**1 hour 45 minutes**

No additional materials are needed.

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- Calculators must **not** be used in this paper.

- The total mark for this paper is 75.
- The number of marks for each question or part question is shown in brackets [ ].
- No marks will be awarded for using brand names of software packages or hardware.

This document has **16** pages. Any blank pages are indicated.

1 Computers can be infected with malware. Spyware is one example of malware.

(a) Tick (✓) **one** box to show a correct definition of spyware.

**A** Software that activates a webcam and transmits the video to a third party that outputs it live on a website.

☐

**B** Software that detects when a password is being entered and then emails the password to a third party.

☐

**C** Software that records all data entered into a computer, analyses this data to find email addresses and passwords, then posts these to a website.

☐

**D** Software that records all key presses and transmits these to a third party.

☐

[1]

(b) Complete the table by identifying and describing **two** other examples of malware.

|   | Malware                           | Description  |
|---|-----------------------------------|--|
| 1 | <div>.....</div> <div>.....</div> | <div>.....</div> <div>.....</div> <div>.....</div> <div>.....</div> <div>.....</div> |
| 2 | <div>.....</div> <div>.....</div> | <div>.....</div> <div>.....</div> <div>.....</div> <div>.....</div> <div>.....</div> |

[6]

(c) Proxy-servers and firewalls have some similar functions.

Identify **two** similarities and **one** difference between proxy-servers and firewalls.

Similarity 1 .....

.....

.....

Similarity 2 .....

.....

.....

Difference .....

.....

.....

[3]

- 2 A programmer has designed a three-dimensional (3D) interactive computer game. They are going to develop a program for the game. The program needs to run efficiently, but it must also be developed as soon as possible.

- (a) Tick (✓) **one** box to identify whether the programmer should use a high-level language or a low-level language to develop the program.

Explain the reasons for your choice.

High-level language

☐

Low-level language

☐

Reasons for your choice .....

.....

.....

.....

.....

.....

.....

.....

..... [4]

- (b) If the programmer chooses a high-level language, they can use a compiler or an interpreter to translate the high-level language into a low-level language.

Describe the operation of a compiler and of an interpreter.

Compiler .....

.....

.....

.....

Interpreter .....

.....

.....

.....

[4]

3 A new computer comes with primary and secondary storage.

(a) Data storage is measured using binary denominations.

Complete each conversion.

8 bytes = ..... nibbles

512 kibibytes (KiB) = ..... mebibytes (MiB)

4 gibibytes (GiB) = ..... mebibytes (MiB)

1 exbibyte (EiB) = ..... pebibytes (PiB)

[4]

Working space

.....

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.....

(b) Random access memory (RAM) is an example of primary storage.

Give **three** examples of data that is commonly stored in RAM.

1 .....

2 .....

3 .....

[3]

(c) Describe the purpose of secondary storage.

.....

.....

.....

..... [2]

- 4 A wildlife photographer stores their digital images on a computer.

(a) Complete the table by defining each term about images.

| Image term | Definition                             |
|------------|--|
| pixel      | <p>.....</p> <p>.....</p> <p>.....</p> |
| resolution | <p>.....</p> <p>.....</p> <p>.....</p> |

[2]

- (b) One of the images has a resolution of  $1000 \times 1000$  and a colour depth of 2 bytes.

Calculate the file size of the image. Give your answer in bytes.

Show your working.

Working space .....

.....

.....

.....

File size ..... bytes

[2]

- (c) The photographer decides to purchase a solid-state storage device to back up their images.

Complete the description of solid-state storage.

Use the terms from the list.

Some of the terms in the list will **not** be used. You should only use a term once.

binary    denary    electrons    grid    neutrons  
non-volatile    RAM    star    transistors    virtual    volatile

Solid-state storage is ..... This means that the data is **not** lost when the power is turned off.

Solid-state storage is made of ..... that are laid out in a .....

Gates are used to control the flow of the ..... through the transistors. This changes the data in the transistors from 1 to 0, or from 0 to 1.

[4]

- (d) The photographer compresses an image file before it is emailed.

Give **one** reason why a file is compressed.

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

- 5 A website allows users to purchase items.

Computer A sends a request for the homepage to the website's server.

- (a) The request is sent using packet switching.

The structure of a packet of data has three elements. One element is the packet header.

- (i) Identify **two** items of data contained in a packet header.

1 .....

2 ..... [2]

- (ii) Identify the **two** other elements of a packet.

1 .....

2 ..... [2]



(b) Computer A needs to be directly connected to a router that is located in a different room.

- (i) Tick (✓) **one** box to identify whether serial data transmission or parallel data transmission is more suitable for this connection.

Explain the reasons for your choice.

Serial data transmission

☐

Parallel data transmission

☐

Reasons for your choice .....

.....

.....

.....

.....

..... [3]

- (ii) The connection will also use full-duplex data transmission.

Define full-duplex data transmission.

.....

.....

.....

..... [2]

(c) The data transmission will use parity checks.

(i) The bytes need to be sent using an even parity byte check.

Complete the parity bit for each byte.

|        | Parity<br>bit |   |   |   |   |   |   |   |
|--------|---------------|---|---|---|---|---|---|---|
| Byte A |               | 1 | 1 | 0 | 0 | 0 | 1 | 1 |
| Byte B |               | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[2]

(ii) A parity block check can be used instead of a parity byte check.

Explain how a parity block check might detect an error in transmission that would **not** be detected by a parity byte check.

.....

.....

.....

..... [2]

- (iii) The data was sent using an even parity block check. One of the bits has been transmitted incorrectly.

|             | Parity bit | Bit 1 | Bit 2 | Bit 3 | Bit 4 | Bit 5 | Bit 6 | Bit 7 |
|-------------|------------|-------|-------|-------|-------|-------|-------|-------|
| Byte 0      | 1          | 1     | 1     | 0     | 1     | 0     | 0     | 0     |
| Byte 1      | 0          | 0     | 1     | 0     | 0     | 1     | 0     | 0     |
| Byte 2      | 1          | 0     | 1     | 1     | 0     | 0     | 0     | 1     |
| Byte 3      | 1          | 1     | 0     | 0     | 1     | 1     | 1     | 1     |
| Byte 4      | 1          | 0     | 1     | 0     | 0     | 0     | 1     | 0     |
| Byte 5      | 0          | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Byte 6      | 0          | 1     | 1     | 1     | 1     | 0     | 0     | 0     |
| Parity byte | 0          | 1     | 1     | 0     | 1     | 0     | 1     | 0     |

Identify the bit number and the byte number of the incorrect bit.

Bit number .....

Byte number .....

[2]

(d) The website allows the user to set up an account to log on and purchase items. The website is accessed and displayed using a web browser.

- (i) Two functions of the web browser are to render hypertext markup language (HTML) to display web pages and to store cookies.

Identify **two** other functions of a web browser.

1 .....

2 ..... [2]

- (ii) Identify **two** ways that cookies can be used to enhance the user's experience of this website.

1 .....

.....

2 .....

..... [2]

**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.

| <b>Movement</b> | <b>Binary</b> | <b>Denary</b> | <b>Hexadecimal</b> |
|-----------------|---------------|---------------|--------------------|
| forward 1 step  | 00011111      | 31            |                    |
| back 1 step     |               | 140           | 8C                 |
| turn right      | 01011010      |               | 5A                 |
| turn left       |               | 120           | 78                 |

[4]

Working space

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**(b)** Describe what is meant by robotics.

.....

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..... [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 AI.

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..... [3]

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

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..... [4]

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# **Cambridge IGCSE™**

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## **COMPUTER SCIENCE**

**0478/12**

Paper 1 Computer Systems

**February/March 2023**

MARK SCHEME

Maximum Mark: 75

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**Published**

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the February/March 2023 series for most Cambridge IGCSE™, Cambridge International A and AS Level components and some Cambridge O Level components.

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This document consists of **10** printed pages.

**Generic Marking Principles**

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

**GENERIC MARKING PRINCIPLE 1:**

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

**GENERIC MARKING PRINCIPLE 2:**

Marks awarded are always **whole marks** (not half marks, or other fractions).

**GENERIC MARKING PRINCIPLE 3:**

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

**GENERIC MARKING PRINCIPLE 4:**

Rules must be applied consistently, e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

**GENERIC MARKING PRINCIPLE 5:**

Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).

**GENERIC MARKING PRINCIPLE 6:**

Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

**Mark scheme abbreviations**

|                  |   |
|------------------|---|
| /                | separates alternative words / phrases within a marking point                |
| //               | separates alternative answers within a marking point                        |
| <u>underline</u> | actual word given must be used by candidate (grammatical variants accepted) |
| max              | indicates the maximum number of marks that can be awarded                   |
| ( )              | the word / phrase in brackets is not required, but sets the context         |

**Note:** No marks are awarded for using brand names of software packages or hardware.

| Question | Answer  | Marks |
|----------|---|-------|
| 1(a)     | D   | 1     |
| 1(b)     | <p><b>One</b> mark for identification. E.g. <b>One</b> mark per bullet for description to <b>max two</b> each.</p> <p>Virus</p> <ul style="list-style-type: none"> <li>• Software/code that replicates</li> <li>• ...when the user runs it // with an active host</li> <li>• Deletes/damages/corrupts data/files // takes up storage/memory space</li> </ul> <p>Worm</p> <ul style="list-style-type: none"> <li>• Software/code that replicates itself on a <b>network</b></li> <li>• ...without user input // without active host</li> <li>• Takes-up bandwidth</li> <li>• Deletes/damages/corrupts data/files // takes up storage/memory space</li> <li>• Opens back doors to computers over the network</li> <li>• Used to deposit other malware on networked computers</li> </ul> <p>Trojan horse</p> <ul style="list-style-type: none"> <li>• Software/code that is hidden within other software // Software that is disguised as authentic software</li> <li>• ...when <b>downloaded/installed</b> the other <b>malware/by example</b> it contains is <b>installed</b></li> </ul> <p>Adware</p> <ul style="list-style-type: none"> <li>• Software/code that generates/displays (unwanted) adverts on a user's computer</li> <li>• Some may contain spyware/other malware</li> <li>• Some when clicked may link to viruses</li> <li>• Reduces device performance // reduces internet speed</li> <li>• Redirects internet searches/user to fake websites</li> </ul> <p>Ransomware</p> <ul style="list-style-type: none"> <li>• Software/code that stops a user accessing/using their computer/data</li> <li>• ...by encrypting the data/files/computer</li> <li>• A <b>fee</b> has to be paid to decrypt the data // A <b>fee</b> has to be paid to 'release' the computer/device/data</li> </ul> | 6     |

| Question | Answer   | Marks    |
|----------|--|----------|
| 1(c)     | <p><b>One</b> mark for each similarity to <b>max two</b>. <b>One</b> mark for difference (both sides needed unless clearly and accurately implied).</p> <p>Similarities e.g.</p> <ul style="list-style-type: none"> <li>• Check incoming and outgoing signals // filter traffic</li> <li>• Store whitelist/blacklist</li> <li>• Block incoming/outgoing signals</li> <li>• Both block unauthorised access</li> <li>• Keep a log of traffic</li> <li>• Both can be hardware or software (or both)</li> </ul> <p>Differences e.g.</p> <ul style="list-style-type: none"> <li>• Proxy can hide user's IP address, firewall does not hide the user's IP address</li> <li>• Proxy intention is to divert attack from server, firewall is to stop unauthorised access</li> <li>• Proxy protects a server, firewall protects individual computer</li> <li>• Proxy examines/processes requests for a website but a firewall does not (checks type of signal) // Proxy <b>processes</b> client-side requests whereas firewall <b>filters</b> packets</li> <li>• Proxy transmits website data to the user, but a firewall does not (it allows valid signals)</li> <li>• Proxy allows faster access to a web page using cache, but a firewall does not (allow faster access or have cache)</li> <li>• Proxy can hide internal network from internet, but a firewall cannot</li> </ul> | <b>3</b> |

| Question | Answer   | Marks    |
|----------|--|----------|
| 2(a)     | <p>No mark for choice.<br/>Any <b>four</b> from matching choice.</p> <p>High-level</p> <ul style="list-style-type: none"> <li>• Easier for programmer to read/write/understand/edit</li> <li>• ... therefore, the programmer is less likely to make mistakes // can write in shorter timeframe</li> <li>• Easier to <b>debug</b> // Easier to find/correct <b>errors</b></li> <li>• ...so, the programmer can find and correct errors in less time</li> <li>• Game will be machine independent // Game will be portable (between hardware)</li> <li>• ...the game can be used on any computer without a need for understanding of the hardware / compilation for that hardware</li> <li>• Programmer can focus on the problem instead of the manipulation of memory/hardware</li> </ul> <p>Low-level</p> <ul style="list-style-type: none"> <li>• More <b>memory/RAM</b> efficient</li> <li>• ... 3D graphics will have high memory consumption anyway</li> <li>• Allows direct manipulation of memory</li> <li>• ... allows for more efficient control/response time</li> <li>• Allows for use of specialised hardware</li> </ul> | <b>4</b> |
| 2(b)     | <p><b>Two</b> from for each compiler and interpreter.</p> <p>Compiler</p> <ul style="list-style-type: none"> <li>• Checks all code <b>before</b> executing any code</li> <li>• Produces error report with all errors found for the whole code (before translating/running any of the code)</li> <li>• Produces executable file</li> </ul> <p>Interpreter</p> <ul style="list-style-type: none"> <li>• Checks/translate one line of code <b>and then</b> executes it before moving on to the next line</li> <li>• Stops when an error is found</li> <li>• ... when corrected the program can be run from the same position // allows error correction in real time</li> </ul>   | <b>4</b> |

| Question | Answer   | Marks    |
|----------|--|----------|
| 3(a)     | <b>One</b> mark each:<br>8 bytes = <b>16</b> nibbles<br>512 KiB = <b>0.5</b> MiB<br>4 GiB = <b>4096</b> MiB<br>1 EiB = <b>1024</b> PiB   | <b>4</b> |
| 3(b)     | Any <b>three</b> from: <ul style="list-style-type: none"> <li>• Currently running data</li> <li>• Currently running (application) software</li> <li>• Currently running instructions</li> <li>• Currently running parts of OS</li> <li>• Currently running utility software</li> </ul> | <b>3</b> |
| 3(c)     | Any <b>two</b> from: <ul style="list-style-type: none"> <li>• For non-volatile/permanent/long-term storage of files/data</li> <li>• To store data that is not currently required by the <b>CPU</b></li> <li>• To store data to transfer it to another computer</li> </ul>              | <b>2</b> |

| Question | Answer   | Marks    |
|----------|--|----------|
| 4(a)     | <b>One</b> mark each:<br><br>Pixel: <ul style="list-style-type: none"> <li>• <b>One</b> square/circle of <b>one</b> colour // the <b>smallest component</b> of the image</li> </ul> Resolution: <ul style="list-style-type: none"> <li>• The number of pixels per set area/cm/inch // the number of pixels wide by the number of pixels high // number of pixels in an image</li> </ul>                                | <b>2</b> |
| 4(b)     | <b>One</b> mark for answer: <ul style="list-style-type: none"> <li>• 2 000 000 bytes</li> </ul> <b>One</b> mark for working from: <ul style="list-style-type: none"> <li>• <math>1000 \times 1000 (= 1\,000\,000)</math></li> <li>• <math>1\,000\,000 \times 2 (= 2\,000\,000)</math></li> </ul>   | <b>2</b> |
| 4(c)     | <b>One</b> mark for each term:<br><br>Solid-state storage is <b>non-volatile</b> . This means that the data is <b>not</b> lost when the power is turned off.<br>Solid-state storage is made of <b>transistors</b> that are laid out in a <b>grid</b> .<br>Gates are used to control the flow of the <b>electrons</b> through the transistors.<br>This changes the data in the transistors from 1 to 0, or from 0 to 1. | <b>4</b> |
| 4(d)     | Any <b>one</b> from: <ul style="list-style-type: none"> <li>• Reduce the file size</li> <li>• Increase transmission speed // Reduce transmission time</li> <li>• Reduce <b>storage</b> space required</li> <li>• Less bandwidth required for transmission</li> </ul>   | <b>1</b> |

| Question  | Answer   | Marks    |   |   |   |   |   |   |   |          |   |   |   |   |   |   |   |          |
|-----------|--|----------|---|---|---|---|---|---|---|----------|---|---|---|---|---|---|---|----------|
| 5(a)(i)   | Any <b>two</b> from:<br>e.g. <ul style="list-style-type: none"><li>• <b>Destination</b> IP/address</li><li>• Packet number</li><li>• <b>Originators</b> IP/address</li><li>• Error detection method</li></ul>  | <b>2</b> |   |   |   |   |   |   |   |          |   |   |   |   |   |   |   |          |
| 5(a)(ii)  | <b>One</b> mark each: <ul style="list-style-type: none"><li>• Payload</li><li>• Trailer</li></ul>  | <b>2</b> |   |   |   |   |   |   |   |          |   |   |   |   |   |   |   |          |
| 5(b)(i)   | No mark for choice.<br><b>Three</b> from for justification that matches choice.<br><br>Serial <ul style="list-style-type: none"><li>• Data arrives in order sent // does not need reordering</li><li>• Less likely to experience interference</li><li>• ... less likely to have errors</li><li>• Can transmit over a longer distance (i.e. another room)</li><li>• Still fast transmission...</li><li>• ...sufficient for this purpose</li></ul><br>Parallel <ul style="list-style-type: none"><li>• Faster transmission speed than serial</li><li>• ... faster response to requests</li><li>• Very long connection not needed</li><li>• ...next room is (likely) within distance for parallel</li><li>• ... unlikely to error/arrive out of sequence/skew</li></ul> | <b>3</b> |   |   |   |   |   |   |   |          |   |   |   |   |   |   |   |          |
| 5(b)(ii)  | <b>One</b> mark each: <ul style="list-style-type: none"><li>• Data goes in both directions...</li><li>• ...at the same time</li></ul>  | <b>2</b> |   |   |   |   |   |   |   |          |   |   |   |   |   |   |   |          |
| 5(c)(i)   | <b>One</b> mark each:<br><table border="1"><tr><td><b>0</b></td><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td></tr><tr><td><b>0</b></td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr></table>  | <b>0</b> | 1 | 1 | 0 | 0 | 0 | 1 | 1 | <b>0</b> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | <b>2</b> |
| <b>0</b>  | 1  | 1        | 0 | 0 | 0 | 1 | 1 |   |   |          |   |   |   |   |   |   |   |          |
| <b>0</b>  | 0  | 0        | 0 | 0 | 0 | 0 | 0 |   |   |          |   |   |   |   |   |   |   |          |
| 5(c)(ii)  | <b>One</b> mark each: <ul style="list-style-type: none"><li>• In parity check, <b>interchange</b> of bits will not be detected // Parity check cannot detect <b>even</b> number of changes // Parity check cannot detect error if parity stays correct ...</li><li>• ...the (possible) position of all changes will be highlighted // will identify the horizontal and vertical position of all differences/changes</li></ul>  | <b>2</b> |   |   |   |   |   |   |   |          |   |   |   |   |   |   |   |          |
| 5(c)(iii) | <b>One</b> mark each: <ul style="list-style-type: none"><li>• Bit 6</li><li>• Byte 4</li></ul>   | <b>2</b> |   |   |   |   |   |   |   |          |   |   |   |   |   |   |   |          |



| Question | Answer  | Marks    |
|----------|---|----------|
| 5(d)(i)  | <p>Any <b>two</b> from:</p> <p>e.g.</p> <ul style="list-style-type: none"> <li>Storing bookmarks/favourites</li> <li>Storing history</li> <li>Allow multiple tabs/web pages to be open</li> <li>Allow movement back and forth between web pages // provides navigation tools</li> <li>Allows the user to enter a URL/IP into the address bar</li> <li><b>Manages</b> HTTP/HTTPS protocol</li> <li>Search cache for IP // Request IP from DNS // Send URL to DNS</li> <li>Sends a request to the <b>IP address/web server</b> (to obtain the contents of a web page)</li> <li>Runs active script/JavaScript/client-side script</li> <li>Allows <b>files</b> to be downloaded from <b>website/internet</b></li> </ul> | <b>2</b> |
| 5(d)(ii) | <p>Any <b>two</b> from:</p> <p>e.g.</p> <ul style="list-style-type: none"> <li>Storing preferences // so the user does not have to select their preferences each time they visit the site</li> <li>Storing account details // so the user does not have to remember/enter their username and password each time they visit the site</li> <li>Storing recent purchases // to allow the user to quickly re-order more items</li> <li>Storing the pages visited/items selected // to display relevant adverts</li> <li>Storing shopping basket // so when the user leaves the site the items are still in their basket</li> </ul>  | <b>2</b> |

| Question       | Answer   | Marks    |             |        |             |                |          |    |    |             |          |     |    |            |          |    |    |           |            |     |    |   |
|----------------|--|----------|-------------|--------|-------------|----------------|----------|----|----|-------------|----------|-----|----|------------|----------|----|----|-----------|------------|-----|----|---|
| 6(a)           | <div>One mark each</div> <table><tr><th>Movement</th><th>Binary</th><th>Denary</th><th>Hexadecimal</th></tr><tr><td>forward 1 step</td><td>00011111</td><td>31</td><td>1F</td></tr><tr><td>back 1 step</td><td>10001100</td><td>140</td><td>8C</td></tr><tr><td>turn right</td><td>01011010</td><td>90</td><td>5A</td></tr><tr><td>turn left</td><td>(0)1111000</td><td>120</td><td>78</td></tr></table> | Movement | Binary      | Denary | Hexadecimal | forward 1 step | 00011111 | 31 | 1F | back 1 step | 10001100 | 140 | 8C | turn right | 01011010 | 90 | 5A | turn left | (0)1111000 | 120 | 78 | 4 |
| Movement       | Binary   | Denary   | Hexadecimal |        |             |                |          |    |    |             |          |     |    |            |          |    |    |           |            |     |    |   |
| forward 1 step | 00011111   | 31       | 1F          |        |             |                |          |    |    |             |          |     |    |            |          |    |    |           |            |     |    |   |
| back 1 step    | 10001100   | 140      | 8C          |        |             |                |          |    |    |             |          |     |    |            |          |    |    |           |            |     |    |   |
| turn right     | 01011010   | 90       | 5A          |        |             |                |          |    |    |             |          |     |    |            |          |    |    |           |            |     |    |   |
| turn left      | (0)1111000   | 120      | 78          |        |             |                |          |    |    |             |          |     |    |            |          |    |    |           |            |     |    |   |
| 6(b)           | <div>Any <b>two</b> from:</div> <ul style="list-style-type: none"><li>• The design of robots (to perform tasks/operations/functions)</li><li>• The construction of robots (to perform tasks/operations/functions)</li><li>• The operation of robots (to perform tasks/operations/functions)</li></ul>  | 2        |             |        |             |                |          |    |    |             |          |     |    |            |          |    |    |           |            |     |    |   |

| Question | Answer   | Marks    |
|----------|--|----------|
| 6(c)     | <p><b>Seven</b> from:</p> <ul style="list-style-type: none"> <li>• Uses an infra-red/proximity sensor</li> <li>• Sensor <b>continuously</b> sends the <b>digitised</b> value/reading/distance to the microprocessor</li> <li>• Microprocessor compares the data/signal to the stored value of <b>10</b>(cm)</li> <li>• If the <b>data/signal</b> is <b>greater</b> than the stored value/10 ...</li> <li>• ...a <b>signal</b> is sent to make the <b>robot move</b> forward</li> <li>• If the <b>data/signal</b> is <b>less than or equal</b> to the stored value/10 ...</li> <li>• ...a <b>signal</b> is sent to make robot <b>turn</b></li> <li>• An <b>actuator</b> is used to make the robot <b>turn/move forward</b></li> <li>• The whole process repeats continuously <b>until</b> turned off/stopped</li> </ul> | <b>7</b> |
| 6(d)(i)  | <p>Any <b>three</b> from:<br/>e.g.</p> <ul style="list-style-type: none"> <li>• Collects data</li> <li>• Stores rules for using the data</li> <li>• The ability to reason</li> <li>• The ability to learn // uses machine learning</li> <li>• ... by adapting what it does</li> <li>• ... for example, from mistakes to not make them again // result from previous decisions impacts future</li> <li>• ... by changing its own rules</li> <li>• ...by changing its own data</li> <li>• ...by being trained</li> <li>• Makes one or more predictions (to make a decision)</li> <li>• Find/analyse patterns</li> </ul>  | <b>3</b> |
| 6(d)(ii) | <p><b>Four</b> from:<br/>e.g.</p> <ul style="list-style-type: none"> <li>• Use <b>machine learning</b> algorithms</li> <li>• Collects data about where it has been</li> <li>• Collect data about obstacles/problems</li> <li>• Store successful actions</li> <li>• Stores unsuccessful actions</li> <li>• Identify/store patterns</li> <li>• ... to make sure it does not repeat the same incorrect route</li> <li>• ... so, it knows how to react to obstacles next time</li> <li>• ...so, it knows what is most likely to work next time</li> </ul>  | <b>4</b> |