AS
COMPUTER SCIENCE
7516/2

Paper 2

Mark scheme

June 2022

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Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this mark scheme are available from aqa.org.uk

Level of response marking instructions

Level of response mark schemes are broken down into levels, each of which has a descriptor. The descriptor for the level shows the average performance for the level. There are marks in each level.

Before you apply the mark scheme to a student's answer read through the answer and annotate it (as instructed) to show the qualities that are being looked for. You can then apply the mark scheme.

Step 1 Determine a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the descriptor for that level. The descriptor for the level indicates the different qualities that might be seen in the student's answer for that level. If it meets the lowest level then go to the next one and decide if it meets this level, and so on, until you have a match between the level descriptor and the answer. With practice and familiarity you will find that for better answers you will be able to quickly skip through the lower levels of the mark scheme.

When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best fit approach for defining the level and then use the variability of the response to help decide the mark within the level, ie if the response is predominantly level 3 with a small amount of level 4 material it would be placed in level 3 but be awarded a mark near the top of the level because of the level 4 content.

Step 2 Determine a mark

Once you have assigned a level you need to decide on the mark. The descriptors on how to allocate marks can help with this. The exemplar materials used during standardisation will help. There will be an answer in the standardising materials which will correspond with each level of the mark scheme. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's answer with the example to determine if it is the same standard, better or worse than the example. You can then use this to allocate a mark for the answer based on the Lead Examiner's mark on the example.

You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other valid points. Students do not have to cover all of the points mentioned in the Indicative content to reach the highest level of the mark scheme.

An answer which contains nothing of relevance to the question must be awarded no marks.

To Examiners:

- **When to award '0' (zero) or '–' (hyphen) when inputting marks on CMI+**

  A mark of 0 should be awarded where a candidate has attempted a question but failed to write anything creditworthy.

  Insert a hyphen when a candidate has not attempted a question, so that eventually the Principal Examiner will be able to distinguish between the two (not attempted/nothing creditworthy) in any statistics.

- This mark scheme contains the correct responses which we believe that candidates are most likely to give. Other valid responses are possible to some questions and should be credited. Examiners should refer responses that are not covered by the mark scheme, but which they deem creditworthy, to a **Team Leader**.

The following annotation is used in the mark scheme:

; - means a single mark
// - means an alternative response
/ - means an alternative word or sub-phrase
A. - means acceptable creditworthy answer
R. - means reject answer as not creditworthy
NE. - means not enough
I. - means ignore
DPT. - means "Don't penalise twice". In some questions a specific error made by a candidate, if repeated, could result in the loss of more than one mark. The **DPT** label indicates that this mistake should only result in a candidate losing one mark, on the first occasion that the error is made. Provided that the answer remains understandable, subsequent marks should be awarded as if the error was not being repeated.

Examiners are required to assign each of the candidate's responses to the most appropriate level according to **its overall quality**, and then allocate a single mark within the level.

Qu	Pt	Marking Guidance	Marks
01	1	**Mark is for AO1 (knowledge)** **1 mark** for description Natural numbers are positive numbers (including zero) // integers include negative numbers; **Mark is for AO1 (understanding)** **1 mark** for example Any example of a negative whole number (eg –2, –999);	2

Qu	Pt	Marking Guidance	Marks
01	2	**Mark is for AO1 (knowledge)** **1 mark** for description An irrational number cannot be written as a fraction / ratio / quotient (with an integer numerator and an integer denominator); **Mark is for AO1 (understanding)** **1 mark** for example Any example of an irrational number (eg $\sqrt{2}$, Pi/π or e.) refer to Team leader if unsure; **R.** Any value expressed to a fixed number of decimal places.	2

Qu	Pt	Marking Guidance	Marks
01	3	**Marks are for AO1 (understanding)** **1 mark** per correct lozenge **Counting**: B (Natural); **Measuring**: D (Real); **R.** More than one lozenge shaded in a column.	2

Qu	Pt	Marking Guidance	Marks
02	1	**Mark is for AO2 (application)** 1011 0001;	1

Qu	Pt	Marking Guidance	Marks
02	2	**Mark is for AO2 (application)** C1;	1

Qu	Pt	Marking Guidance	Marks
03	1	**Marks are for AO1 (understanding)** 0; 65535; **A.** $2^{16} - 1$	2

Qu	Pt	Marking Guidance	Marks
03	2	**Marks are for AO2 (application)** **1 mark** for showing three correct products 00010101 00101010 01010100; // 00000111 00011100 01110000; **A.** Omitted leading zeros. **1 mark** for the correct answer if some relevant working is shown. 10010011;	2

Qu	Pt	Marking Guidance	Marks
04	1	**Mark is for AO1 (knowledge)** A (unique) <u>number</u> used to represent a character; **R.** code	1

Qu	Pt	Marking Guidance	Marks
04	2	**Marks are for AO1 (understanding)** Introduced to support a larger range of characters; Due to increased international communication // use of files in multiple countries // requirement to use additional symbols (allow examples, eg mathematical / scientific / engineering / emoji symbols) // facilitates interchange of documents between countries // culturally unacceptable to only allow non-English speaking countries to communicate in English// (concurrent) support for <u>multiple</u> languages; **A.** representation of characters in languages other than English (using codes that are globally unique). **MAX 2**	2

Qu	Pt	Marking Guidance	Marks
04	3	**Marks are for AO1 (understanding)** The number of 1s is summed / counted; if the total is even, the parity bit is set to 0, otherwise it is set to 1 // if the total is odd, the parity bit is set to 1, otherwise it is set to 0 // the parity bit is set to ensure the total number of 1s is even; The bits are XOR'd with each other; and the result is the parity bit; **MAX 2**	2

Qu	Pt	Marking Guidance	Marks
04	4	**Mark is for AO2 (application)** `0;`	1

Qu	Pt	Marking Guidance	Marks
04	5	**Marks are for AO2 (application)** Showing that 'EGG' is represented by 1000101 1000111 1000111; Providing a 21-bit answer that is not 'DAB' or 'EGG'; Correct answer (reached by applying XOR): 0000001 0000110 0000101; **A.** Correct result of XORing 1000100 1000001 1000010 with an incorrect representation of 'EGG'.	3

Qu	Pt	Marking Guidance	Marks
05	1	**Marks are for AO1 (understanding)** Analogue data is continuous // analogue data can take any value in a given range // between any two analogue values there is another value; Digital data has discrete values // can be stored as binary values / 1s and 0s; **A.** Has jumps / gaps between each value.	2

Qu	Pt	Marking Guidance	Marks
05	2	**Marks are for AO1 (understanding)** The ADC takes samples of the (analogue / continuous electrical) <u>signal</u> / <u>voltage</u> / <u>wave</u> at regular intervals; **R.** Sound wave for signal. The samples are quantised // the amplitude (**A.** height) of each sample is approximated to an integer value // the amplitude (**A.** height) of samples are measured; **A.** Voltage for amplitude. **A.** Digital / number / value for integer value. **A.** Explanation of how the signal is quantised. Each sample is assigned a binary value / encoded as a binary value; **A.** Stored / converted so long as sample is stated previously. **R.** Digital value for binary value.	3

Qu	Pt	Marking Guidance	Marks
06	1	**Mark is for AO1 (knowledge)** Software is the name given to programs / code / instructions that are executed;	1
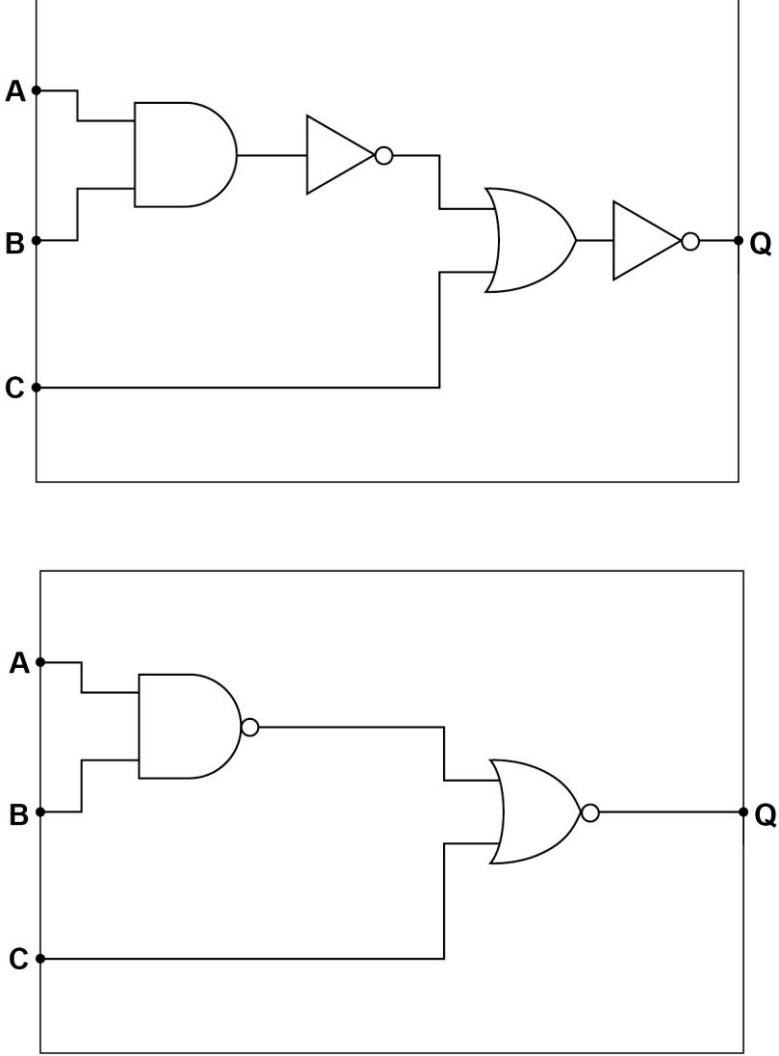
Qu	Pt	Marking Guidance	Marks
06	2	**Marks are for AO1 (knowledge)** Operating systems / OS; Utility programs; Libraries; **A.** Specific examples of utilities (such as virus checker, disk defragmenter) unless the student has already given the type utilities as a response. **R.** Interpreters, compilers, assemblers. **MAX 2**	2

Qu	Pt	Marking Guidance	Marks
06	3	**Marks are for AO1 (understanding)** Software must be used to finish the translation process (on the computer running the program); The (JIT compiler) compiles the intermediate language code / bytecode into machine code for the processor / platform / computer it is being executed on; Use a virtual machine // a just-in-time / JIT compiler; (The virtual machine will) interpret / translate / execute the intermediate language code / bytecode // call functions within its own code to carry out the command; Each processor instruction set / architecture will have its own virtual machine; **MAX 2**	2

Qu	Pt	Marking Guidance	Marks
06	4	**Mark is for AO1 (understanding)** Allows processor / platform independence // code is more portable / cross-platform; Compiler is only required to translate source code once (but the intermediate language / bytecode can still be executed on a variety of platforms); Can create intermediate language code / bytecode for a specific (standardised) virtual machine that all the target machines have installed; The virtual machine can perform security checks on the (intermediate language / byte) code without execution, hence it is more secure; **MAX 1**	1

Qu	Pt	Marking Guidance	Marks
07	1	**Mark is for AO1 (knowledge)** NOR;	1

Qu	Pt	Marking Guidance	Marks
07	2	**Mark is for AO1 (knowledge)** NAND; **R.** NOT AND	1

Qu	Pt	Marking Guidance	Marks
07	3	**Marks are for AO2 (application)** **1 mark** for each design point A and B are connected to the inputs of an AND gate and the output of the AND gate connected to the input of a NOT gate // A and B connected to the inputs of a NAND gate; The final two gates in the circuit are an OR gate followed by a NOT gate // The final gate in the circuit is a NOR gate; **A.** award 2 marks if the candidate has correctly simplified the Boolean expression and drawn a fully correct logic circuit. **MAX 1** if circuit does not correctly reflect the Boolean expression. **Possible answers:** 	2

Qu	Pt	Marking Guidance	Marks
07	4	**Marks are for AO2 (analyse)** **1 mark** for showing the correct truth table column for $(A+\bar{B})\cdot B$; **1 mark** for showing the correct truth table column for $(A+\bar{B})$;	3

A	B	$\bar{B}$	$(A+\bar{B})$	$(A+\bar{B})\cdot B$
0	0	1	1	0
0	1	0	0	0
1	0	1	1	0
1	1	0	1	1

1 mark for showing the correct answer as $A \cdot B$;

Qu	Pt	Marking Guidance	Marks
07	5	**Marks are for AO2 (application)** **Marking guidance for examiners** • Award marks for working out until an incorrect step has been made. • If, in any one step, a candidate is simplifying different parts of an expression simultaneously award all relevant marks for this multiple stage but don't award any further marks for working in any parts simplified incorrectly. For example, if the expression P.P.(P+Q) + P.P.1 was changed to P.(P+Q)+P.0, the candidate would get one mark for simplifying the first part to P.(P+Q) and could get further marks for correctly simplifying this part of the expression further but should not be awarded marks for simplifying the incorrectly changed part P.0 (ie to 0). **1 mark** for final answer of $A \cdot \bar{B}$; **3 marks** for working **MAX 3** for working. Award up to two marks for applying each of the three techniques (one mark per application) to produce a simpler expression. • Applying De Morgan's Theorem. • Multiply and/or factorise brackets. • Using a law or identity. **Note:** A simpler expression is one that is logically equivalent to the original expression but uses fewer logical operators. **Example 1:**	4

Example 1:

$\left(A+\bar{B}\right) \cdot \left(\overline{\bar{A}+B}\right)$	DMT
$\left(A+\bar{B}\right) \cdot \left(A \cdot \bar{B}\right)$	Multiply brackets
$A \cdot A \cdot \bar{B} + \bar{B} \cdot A \cdot \bar{B}$	X.X = X
$A \cdot \bar{B} + \bar{B} \cdot A$	X + X = X
$A \cdot \bar{B}$	

Example 2:

$\left(A+\bar{B}\right) \cdot \left(\overline{\bar{A}+B}\right)$	DMT
$\overline{\overline{\left(A+\bar{B}\right)}+\left(\bar{A}+B\right)}$	DMT
$\overline{\bar{A} \cdot B+\left(\bar{A}+B\right)}$	A + (A.X) = A
$\overline{\bar{A}+B}$	DMT
$A \cdot \bar{B}$	

Qu	Pt	Marking Guidance	Marks
08	1	**Marks are for AO1 (understanding)**	3

	Description	Order (1 to 4)
A	The contents of the MBR are copied to the CIR.	**2**
B	The contents of the PC are copied to the MAR.	**1**
C	The Control Unit decodes the contents of the CIR.	**3**
D	The result of the calculation is stored.	**4**

3 marks for all correct

2 marks for two correct

1 mark for one correct

R. Labels used more than once.

Qu	Pt	Marking Guidance	Marks
08	2	**Marks are for AO1 (understanding)**	2

Main memory stores the <u>instructions</u> to be executed (and any data required by those instructions);

Main memory returns the instructions / data / value stored in a memory location (specified on the address bus) (using the data bus);

Program is transferred from secondary storage into main memory (if program not already in main memory) when program execution is requested;

Main memory stores any value / data resulting from the execution of the program;

MAX 2

Qu	Pt	Marking Guidance	Marks
08	3	**Mark is for AO1 (knowledge)**	1

Arithmetic logic unit // ALU;

Qu	Pt	Marking Guidance	Marks
08	4	**Mark is for AO1 (understanding)** Increases the amount of data that can be transferred over the bus <u>at once</u>; **A.** Fewer transfers are needed to transfer the same amount of data; **NE.** Data can be transferred quicker / more data per unit of time. **NE.** More data can be transferred. **MAX 1**	1

Qu	Pt	Marking Guidance	Marks
08	5	**Marks are for AO1 (understanding)** The address bus; Width increased <u>by 1</u>;	2

Qu	Pt	Marking Guidance	Marks
09	1	**Mark is for AO1 (understanding)** **B** MOV R3, #42; **R.** More than one lozenge shaded.	1

Qu	Pt	Marking Guidance	Marks

09	2	**Marks are for AO3 (programming)**
		
		 1 mark for each program point
		
		 • Loading value from 101 into R1 (eg LDR R1, 101).
		 • Comparing R1 against the operand 50 (eg CMP R1, #50).
		 • Branching using BGT and BEQ, or BLT, with a suitable label.
		 • Using a logical shift left to double the number (eg LSL R1, R1, #1).
		 • Storing the value (even if incorrect) in R1 back to memory location 101
		
		 Max 3 marks for programming if any syntax incorrect or program does not work correctly under all circumstances.
		
		 Max 4
		
		 Example 1:
		
		 ``` LDR R1, 101 CMP R1, #50 BGT end BEQ end LSL R1, R1, #1 STR R1, 101 end: ```
		
		 Example 2:
		
		 ``` LDR R1, 101 CMP R1, #50 BLT lessThan HALT lessThan: LSL R1, R1, #1 STR R1, 101 ```
		
		 Example 3:
		
		 ``` LDR R1, 101 CMP R1, #50 BLT Double B EndIf Double: LSL R1, R1, #1 STR R1, 101 EndIf: ```
		 A. Use of any valid register number 0-12 instead of R1 .
		 A. Use of comparisons that achieve the same result (eg greater than 49).
		 A. Any label names.
		 A. Alternative methods for doubling a number.
		 A. Inline label names.
		 I. Missing commas.
			4

Qu	Pt	Marking Guidance	Marks
10	1	**Marks are for AO1 (understanding)** **Purpose of start bit (Max 1)** Start the receiver clock (ticking); **A.** To wake up the receiver. Synchronise / bring into phase the clock in the transmitter to the receiver clock; **A.** To synchronise the receiver and transmitter clocks. **NE.** Synchronise the (two) clocks. **Purpose of stop bit (Max 1)** Allows the next start bit to be recognised; Provides time for the receiver to process / transfer the received data; **A.** Allows received data to be processed. **NE.** Signals received data can be processed.	2

Qu	Pt	Marking Guidance	Marks
10	2	**Mark is for AO1 (knowledge)** A set of <u>rules</u> (governing communication between devices); **R.** instructions	1

Qu	Pt	Marking Guidance	Marks
10	3	**Mark is for AO1 (knowledge)** Latency is the (measure of) delay between an action being initiated and its effect being observable // the time taken for data to get to its destination (and back);	1

Qu	Pt	Marking Guidance	Marks
10	4	**Marks are for AO1 (understanding)** Use a bus transmission protocol; **A.** examples of bus protocols eg CSMA/CD. Use appropriate (physical) switching // (switch) creates temporary buses between two nodes; **A.** hub transmits data to all devices	2

Qu	Pt	Marking Guidance	Marks
11		**Marks are for AO2 (analyse)**	12

Level of response question:

Level	Description	Mark Range
4	A line of reasoning has been followed to produce a coherent, relevant, substantiated and logically structured response. Answers in this level will demonstrate a clear justification of the use of lossy compression and will show a developed awareness of how the benefits of lossy compression are related to one another. The response covers **all four** aspects (lossy, ethical, legal, cultural) of the question. A range of the points made will have been expanded upon using clear examples and references to real world implications.	10–12
3	A line of reasoning has been followed to produce a coherent, relevant, substantiated and logically structured response. Answers in this level will address the use of lossy compression but there may not always be a clearly demonstrated understanding of the benefits. The response covers **at least three** aspects (lossy, ethical, legal, cultural) of the question. Some of the points made will have been expanded on and some of these will have been expanded upon using examples but these might not always exemplify the points made or be lacking in references to real world implications.	7–9
2	A line of reasoning has been followed to produce a mostly coherent, relevant, substantiated and logically structured response. The response lists some issues that are likely to focus on only **two or three** aspects (lossy, ethical, legal, cultural) of the question. Some of the points made will have been expanded upon but are likely to be lacking in clear examples or may not wholly relate to the points being made.	4–6
1	There is no evidence that a line of reasoning has been followed. Answers in this level may identify a point relating to the use of lossy compression but this part of the question may not be addressed at all. The response will attempt to identify some issues raised by the question; points are not likely to be expanded upon but where they are, the examples will be irrelevant or not relate to the points being made.	1–3

Indicative Content

Justifying lossy compression:

- Scale / volume of data: the company has a large volume of audio to store (because of the number of users that could have the smart speaker).
- Size of files: lossy compression can reduce the file size (of individual audio files to be transmitted/stored) // greater compression than lossless.
- Audio quality: it is still possible for files to retain (sufficient) quality (to permit analysis) // the audio quality depends on the amount of information retained / lost after applying lossy compression // remove unnecessary / redundant data.

Ethical, legal and cultural examples are likely to overlap; when marking student responses, credit should be given for the range and clarity of points made, regardless of category. Points could include:

Ethical:

- The company has a justifiable goal, (ie by seeking to provide voice controls and improve its algorithms, the company is benefitting its customers, particularly individuals who cannot use traditional input methods).
- The company may record activity that is illegal, raising questions about its responsibility to report the activity to the authorities and duty of care to customers.
- Company employees may misuse the recordings for their own purposes.
- Company employees may be exposed to inappropriate material, raising questions about the duty of care that the company has for its employees.
- Creating 'a slippery slope' through the recordings, ie if the company is allowed to record customers for this purpose, where will it stop?
- The company is contributing to an erosion of privacy for individuals in their home / increasing existing surveillance.
- The company should obtain permission / consent from users before recording them in clear and understandable terms so that customers are providing informed consent.
- There is the potential for increased distrust between users and the company.
- The company may use the recordings for purposes other than improving the voice recognition algorithms.

Legal:

- The company must comply with legislation specifically covering the transmission and storage of data across different countries / territories of operation, including the General Data Protection Regulation (GDPR) or the Data Protection Act.
- The company has a responsibility to ensure their security / integrity / confidentiality / availability of the customer data it stores.
- The company must introduce controls to take account of individual privacy rights / legislation across different countries / territories of operation.
- The international nature of the company means that it may have opportunities to circumvent legislation within particular / different countries / territories, eg by getting user permission to transmit data to and store data in less restrictive countries / territories.

Cultural:

- All users being recorded can have benefits for groups of users with languages / dialects / accents where data is not widely available (even within the same country / territory).
- All users being recorded can allow the algorithms to advance more quickly, potentially allowing the company to make its products available across languages / user groups / countries / territories more quickly.
- The company should consider the customs and cultural norms of its different users (religions) / countries / territories of operation, particularly with regard to respecting expectations of privacy.
- Weighing up the benefit to specific user groups who rely more heavily on voice control, (eg individuals with physical disabilities) against the compromised privacy.

Students may be awarded marks for individual issues or expansions upon issues.

Expansion points may include further details on how the issue may arise or the impact of the issue occurring.

Examples of expansion points could include:

- Company employees might lose or leak data due to coercion or inexperience.
- If a personally identifiable recording is lost or leaks, there may be severe personal and/or professional consequences for the user(s) on the recording.