

International Advanced Level in Computer Science

Unit 3: Advanced Principles of Computer Science

Mark Scheme

General marking guidance

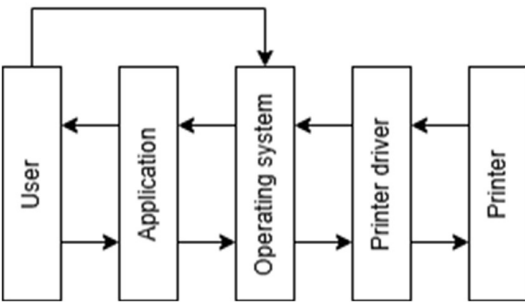
- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed-out work should be marked UNLESS the candidate has replaced it with an alternative response.

Specific marking guidance

- For explanations, justification points that are not linked to a correct identification should not be rewarded.

This mark scheme includes colour coded text. Centres must ensure that all hard copies are printed in full colour so that assessment guidance is accurately conveyed.

Question number	Answer	Additional Guidance	Mark
1	<p>The only correct answer is C</p> <p>A is not correct because MIMD is typically used for general parallel processing and distributed computing</p> <p>B is not correct because MISD has limited practical use in fault tolerant systems</p> <p>D is not correct because SISD is used for basic sequential computing tasks</p>	<p>The correct answer is: C Single Instruction Multiple Data (SIMD).</p>	1

Question number	Answer	Additional Guidance	Mark
2	<p>Award one mark for each of the following up to a maximum of two marks:</p> <ul style="list-style-type: none"> • Operating system/OS (1) • Printer driver/Device driver (1) <p>Exemplar answer:</p>  <pre> graph TD User[User] --> Application[Application] Application --> OS[Operating system] OS --> User OS --> PD[Printer driver] PD --> Printer[Printer] </pre>		2

Question number	Answer	Additional Guidance	Mark
3(a)	<p>Award up to two marks for a linked definition that makes reference to:</p> <ul style="list-style-type: none"> • An emulation of an existing computer system (1) running on a different physical computer system (1) • An emulation of a guest operating system (1) running on a different host operating system (1) <p>Accept any other appropriate response.</p>		2

Question number	Answer	Additional Guidance	Mark
3(b)	<p>Award one mark for an identification point and one mark for an appropriate linked justification, up to a maximum of two marks.</p> <ul style="list-style-type: none"> • Testing will not harm the host machine (1) because the virtual machine acts as a sandbox / can easily be reset (1) • There is no need for multiple physical platforms (1) because multiple virtual machines for different platforms can be installed on the host (1) <p>Accept any other appropriate response.</p>		2

Question number	Answer	Additional Guidance	Mark
4	<p>Award one mark for an identification point and one mark for an appropriate linked justification, up to a maximum of two marks.</p> <ul style="list-style-type: none"> • Performance is improved (1) because parallel access to data and instructions is possible (1) • Optimised/improved use of memory (1) because instruction and data memory sizes can be different (1) • Greater security from malicious code (1) because data cannot be executed as code / instructions cannot be over-written (1) <p>Accept any other appropriate response.</p>	Do not accept generic faster/quicker/more efficient without qualification.	2

Question number	Answer	Additional Guidance	Mark
5(a)	<p>Award one mark for:</p> <ul style="list-style-type: none"> • Reduced Instruction Set Computer (1) 		1

Question number	Answer	Additional Guidance	Mark
5(b)	<p>Award one mark for an identification point and one mark for an appropriate linked justification, up to a maximum of two marks.</p> <ul style="list-style-type: none"> • Devices using RISC architecture have a lower power consumption (than CISC) (1) because they use fewer transistors (1) • Devices using RISC architecture have a lower power consumption (than CISC) (1) because they require fewer complex decoding/logic components (1) <p>Accept any other appropriate response.</p>		2

Question number	Answer	Additional Guidance	Mark
6	<p>Award one mark for each appropriate point given in the correct order, up to a maximum of three marks.</p> <ul style="list-style-type: none"> • The analogue temperature signals are sampled at regular intervals (1) and these samples are then quantised to discrete values within a set range (1) and then encoded as a fixed number of bits (1) <p>Accept any other appropriate response.</p>		3

Question number	Answer	Additional Guidance	Mark																																																																																				
7	<p>Award one mark for each of the following up to a maximum of three marks:</p> <ul style="list-style-type: none"> • Instruction A pipeline stages completed over clock cycle 1 to 5 (1) • Instruction B, C, D and E Instruction Fetch follows Instruction A Fetch in sequence in cycles 2 to 5 (1) • Remaining pipeline stages for instructions B, C, D and E follow A (1) <p>Exemplar answer:</p> <table border="1"> <thead> <tr> <th colspan="2"></th> <th colspan="10">Clock cycle</th> </tr> <tr> <th>Pipeline stage</th> <th>1</th> <th>2</th> <th>3</th> <th>4</th> <th>5</th> <th>6</th> <th>7</th> <th>8</th> <th>9</th> <th>10</th> <th></th> </tr> </thead> <tbody> <tr> <td>IF</td> <td>A</td> <td>B</td> <td>C</td> <td>D</td> <td>E</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>ID</td> <td></td> <td>A</td> <td>B</td> <td>C</td> <td>D</td> <td>E</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>EX</td> <td></td> <td></td> <td>A</td> <td>B</td> <td>C</td> <td>D</td> <td>E</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>MEM</td> <td></td> <td></td> <td></td> <td>A</td> <td>B</td> <td>C</td> <td>D</td> <td>E</td> <td></td> <td></td> <td></td> </tr> <tr> <td>WB</td> <td></td> <td></td> <td></td> <td></td> <td>A</td> <td>B</td> <td>C</td> <td>D</td> <td>E</td> <td></td> <td></td> </tr> </tbody> </table>			Clock cycle										Pipeline stage	1	2	3	4	5	6	7	8	9	10		IF	A	B	C	D	E							ID		A	B	C	D	E						EX			A	B	C	D	E					MEM				A	B	C	D	E				WB					A	B	C	D	E			<p>Mark points colour coded:</p> <p>BP1 BP2 BP3</p>	3
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8	<p>Award one mark for an identification point and one mark for an appropriate linked justification, up to a maximum of two marks.</p> <ul style="list-style-type: none"> The pipeline would need to be reset/flushed (1) because the next instruction in the pipeline is not the next instruction that needs to be executed (1) The contents of the pipeline would need to be discarded (1) because the instruction branched to is not the next instruction in the pipeline (1) <p>Accept any other appropriate response.</p>		2

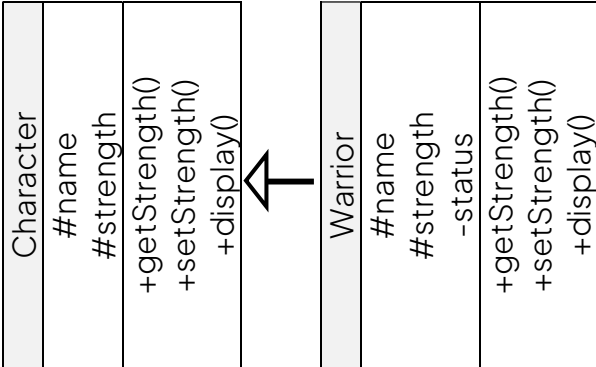
Question number	Answer	Additional Guidance	Mark
9	<p>The only correct answer is D</p> <p>A is not correct because it defines unsupervised learning B is not correct because it defines reinforcement learning C is not correct because it describes supervised learning</p>	<p>The correct answer is: D it uses multilayered neural networks to simulate the complex decision-making power of the human brain.</p>	1

Question number	Answer	Additional Guidance	Mark						
10	<p>Award one mark for each of the following up to a maximum of two marks:</p> <table border="1"> <thead> <tr> <th>Quantum computing term</th> <th>Definition</th> </tr> </thead> <tbody> <tr> <td>(Quantum) Superposition (1)</td> <td>The state in which a quantum particle or system can represent not just one possibility, but a combination of multiple possibilities.</td> </tr> <tr> <td>Qubit (1)</td> <td>The basic unit of quantum information, which is the quantum version of the classic binary bit.</td> </tr> </tbody> </table>	Quantum computing term	Definition	(Quantum) Superposition (1)	The state in which a quantum particle or system can represent not just one possibility, but a combination of multiple possibilities.	Qubit (1)	The basic unit of quantum information, which is the quantum version of the classic binary bit.		2
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Question number	Answer	Additional Guidance	Mark
11	<p>Award one mark for each appropriate point given in the correct order, up to a maximum of three marks:</p> <ul style="list-style-type: none"> A message/document is hashed (1) then a message digest is generated (1) which is then encrypted with the sender's private key (1) <p>Accept any other appropriate wording/phrasing.</p>		3

Question number	Answer	Additional Guidance	Mark
12	<p>Award one mark for an identification point and one mark for an appropriate linked justification, up to a maximum of two marks.</p> <ul style="list-style-type: none"> The (cryptographic) hash of block 2 will not match the publicly distributed ledger value recorded (1) because hashing different data produces a different hash value (1) The (cryptographic) hash of block 2 will have changed (1) because each block contains the hash of the previous block (1) Changing one block invalidates the following chain (1) because all succeeding blocks incorporate data from preceding blocks (1) <p>Accept any other appropriate response.</p>		2

Question number	Answer	Additional Guidance	Mark
13	<p>Award up to two marks for a linked definition that makes reference to:</p> <ul style="list-style-type: none"> Different objects can respond to the same method in different ways (1) based on their specific class type (1) A derived/child class can override a method with the same name in the base/parent class (1) to exhibit different behaviour (1) <p>Accept any other appropriate response.</p>		2

Question number	Answer	Additional Guidance	Mark														
14	<p>Award one mark for each of the following up to a maximum of four marks:</p> <ul style="list-style-type: none"> • +getStrength(), +setStrength() and +display() are public methods in both Character and Warrior classes (1) • #name and #strength are protected attributes of Character (1) • #name and #strength are protected attributes of Warrior (1) • -status is a private attribute of Warrior only (1) <p>Exemplar answer:</p> <table border="1"> <tr> <td>Character</td> <td>Warrior</td> </tr> <tr> <td>#name</td> <td>#name</td> </tr> <tr> <td>#strength</td> <td>#strength</td> </tr> <tr> <td>+getStrength()</td> <td>-status</td> </tr> <tr> <td>+setStrength()</td> <td>+getStrength()</td> </tr> <tr> <td>+display()</td> <td>+setStrength()</td> </tr> <tr> <td></td> <td>+display()</td> </tr> </table> 	Character	Warrior	#name	#name	#strength	#strength	+getStrength()	-status	+setStrength()	+getStrength()	+display()	+setStrength()		+display()	<p>Allow transcription errors as long as intent is clear.</p> <p>Do not award incorrect use of +, -, (), #</p> <p>Award only attributes in centre cells and only methods in lower cells.</p> <p>Award any order within the correct cell.</p> <p>Ignore case and minor transcription errors.</p>	4
Character	Warrior																
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15	<p>Award one mark for each of the following up to a maximum of six marks:</p> <ul style="list-style-type: none"> • Initialisation of R0 to R3 (1) • R4 calculation to determine if R1 is odd (1) • R5 calculation to multiply R0 and update answer in R4 (1) • R2 calculation to increment R2 and integer divide R1 by 2 (1) • All final register values correctly calculated (1) • Purpose of algorithm given as to multiply the values given in R0 and R1 together and place the answer in R3 (1) <p>Exemplar answer:</p> <table border="1"> <thead> <tr> <th>R0</th> <th>R1</th> <th>R2</th> <th>R3</th> <th>R4</th> <th>R5</th> </tr> </thead> <tbody> <tr> <td>6</td> <td>5</td> <td>0</td> <td>0</td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td>5</td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td>1</td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> <td>6</td> <td></td> <td>6</td> </tr> <tr> <td></td> <td>2</td> <td>1</td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td>2</td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td>0</td> <td></td> </tr> <tr> <td></td> <td>1</td> <td>2</td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td>1</td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td>1</td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> <td>30</td> <td></td> <td>24</td> </tr> <tr> <td></td> <td></td> <td>3</td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td>0</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>6</td> <td>0</td> <td>3</td> <td>30</td> <td>1</td> <td>24</td> </tr> </tbody> </table> <p>Program function</p> <p>Multiply the values in R0 and R1 and place result in R3</p>	R0	R1	R2	R3	R4	R5	6	5	0	0							5						1					6		6		2	1														2						0			1	2								1						1					30		24			3					0					6	0	3	30	1	24	<p>Mark points in the trace table are colour coded:</p> <p>BP1 BP2 BP3 BP4 BP5 BP6</p>	6
R0	R1	R2	R3	R4	R5																																																																																														
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16	Award one mark for: <ul style="list-style-type: none"> • Availability (1) 		1

Question number	Answer	Additional Guidance	Mark
17	Award one mark for: <ul style="list-style-type: none"> • DNS/Domain Name System (1) 		1

Question number	Answer	Additional Guidance	Mark
18	The only correct answer is D Answer A, B and C have all been transmitted using even parity.	The correct answer is: D 1010 0100	1

Question number	Answer	Additional Guidance	Mark
19	<p>Award one mark for each appropriate point given in the correct order, up to a maximum of two marks:</p> <ul style="list-style-type: none"> • Electrical signals from a controller are received (1) then converted into physical outputs (1) • A control signal operates an energy source (1) to perform a mechanical operation (1) <p>Accept any other appropriate response.</p>		2

Question number	Answer	Additional Guidance	Mark
20	<p>Award one mark for an identification point and one mark for an appropriate linked justification, up to a maximum of two marks.</p> <ul style="list-style-type: none"> • A request to resend (a corrupted packet) can be sent to the sender (1) because the source IP address can be set as the destination address (1) • Firewall can block the packet being transmitted/received (1) because packets from specific source IP addresses can be blocked (1) <p>Accept any other appropriate response.</p>		2

Question number	Answer	Additional Guidance	Mark
21	<p>Award one mark for an identification point and one mark for an appropriate linked justification, up to a maximum of two marks.</p> <ul style="list-style-type: none"> • RSA encryption would take too long to crack (using brute force) (1) because factoring a very large number into its two prime factors has no polynomial time algorithm (1) • Two very large primes multiplied together form a secure key (1) because factoring the resultant key has no polynomial time algorithm (1) • The product of two primes p and q ($n = pq$) can be computed in polynomial time (1) whereas factoring the product n back into p and q takes exponential time (1) <p>Accept any other appropriate response.</p>	Accept “reasonable time” as an alternative to polynomial time.	2

Question number	Answer	Additional Guidance	Mark
22	<p>Award one mark for:</p> <ul style="list-style-type: none"> • Adding/removing an edge takes $O(1)$ time / is faster (1) • Determining if two nodes are connected takes $O(1)$ time / is faster (1) <p>Accept any other appropriate response.</p>		2

Question number	Answer	Additional Guidance	Mark
23(a)	<p>Award one mark for each appropriate point given in the correct order, up to a maximum of four marks:</p> <ul style="list-style-type: none"> Purple is first compared to the root/Pink(1) it is greater (than the root/Pink so the right subtree is searched) (1) it is less than Red (so the left subtree is searched) (1) and is then compared to Purple so a (match is found) (1) <p>Accept any other appropriate response.</p>		4

Question number	Answer	Additional Guidance	Mark
23(b)	<p>Award one mark for:</p> <ul style="list-style-type: none"> Pre-order (traversal) (1) 		1

Question number	Answer	Additional Guidance	Mark
24	<p>Award one mark for each appropriate point in a linked response up to a maximum of four marks:</p> <ul style="list-style-type: none"> The function count() is called with HeadPointer as the argument (1) 0 is returned if the base case pointer equals None (1), otherwise the function returns 1 plus (1) the recursive call to the current node's next pointer (1) <p>Accept any other appropriate response.</p>	<p>Allow responses that use relevant code such as:</p> <pre>def count (node) : if node == None: return 0 else: return 1 + count (node.next)</pre>	4

Question number	Answer	Additional Guidance	Mark
25	<p>The only correct answer is D.</p> <p>A is incorrect because it describes logarithmic complexity B is incorrect because it describes constant complexity C is incorrect because it describes exponential complexity</p>	<p>The correct answer is: D - Its run time grows in direct proportion to the number of items to process is the correct answer.</p>	1

Question number	Answer	Additional Guidance	Mark						
26	<p>Award one mark for each of the following up to a maximum of two marks:</p> <table border="1"> <thead> <tr> <th>Operation</th> <th>Average case</th> </tr> </thead> <tbody> <tr> <td>Binary search</td> <td>$O(\log n)$ (1)</td> </tr> <tr> <td>Merge sort</td> <td>$O(n \log n)$ (1)</td> </tr> </tbody> </table>	Operation	Average case	Binary search	$O(\log n)$ (1)	Merge sort	$O(n \log n)$ (1)		2
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Question number	Answer	Additional Guidance	Mark
27	<p>Award one mark for each appropriate point in a linked response up to a maximum of two marks:</p> <ul style="list-style-type: none"> • Values less than the pivot are placed to the left of it (1) and values greater than the pivot are placed to the right of it (1) <p>Accept any other appropriate response.</p>		2

Question number	Answer	Additional Guidance	Mark
28	<p>Award one mark for an identification point and one mark for an appropriate linked justification, up to a maximum of two marks.</p> <ul style="list-style-type: none"> • Heuristic rules can be applied (1) so that a solution that runs in polynomial time can be produced (1) • The problem can be reframed/relaxed using heuristics (1) to allow an approximation to an optimal solution to be found (1) <p>Accept any other appropriate response.</p>		2

Question number	Answer	Additional Guidance	Mark
29	<p>Award four marks for a fully correct expression:</p> <ul style="list-style-type: none"> • $A.B + B.\bar{D} + \bar{A}.\bar{B}.D$ (4) <p>OR</p> <p>Award one mark for any of the following up to a maximum of three marks for working:</p> <ul style="list-style-type: none"> • $A.B$ (1) • $B.\bar{D}$ (1) • $\bar{A}.\bar{B}.D$ (1) • Each product term connected with a logical or (1) 	<p>Accept AB instead of $A.B$</p> <p>Do not accept $\bar{A}\bar{B}$ instead of $\bar{A}.\bar{B}$</p> <p>Do not accept answers that are not given in the correct notation.</p>	4

Question number	Answer	Additional Guidance	Mark
30	<p>Award one mark for each of the following up to a maximum of three marks:</p> <ul style="list-style-type: none"> • Correct application of De Morgan's Laws (1) • Correct application of Distributive Law (1) • Fully correct expression (1) <p>Exemplar full method:</p> $\bar{X}.\bar{Y} + Y.\bar{X} \text{ or } \overline{\bar{X}.\bar{Y}} + Y.\bar{X}$ $X.Y + Y.\bar{X}$ $Y.(X + \bar{X})$ $Y.1$ Y	$\bar{X}.\bar{Y} + Y.\bar{X}$ or $\overline{\bar{X}.\bar{Y}} + Y.\bar{X}$ De Morgan's Law $X.Y + Y.\bar{X}$ Double negation Law $Y.(X + \bar{X})$ Distributive Law $Y.1$ Annulment Law Y Identity Law	3

Question number	Answer	Additional Guidance	Mark																																							
31	<p>Award one mark for each of the following up to a maximum of six marks:</p> <ul style="list-style-type: none"> • Rows A, B and C (1) • Row D (1) • Rows E and F (1) • Rows G and H (1) • Shortest path ACDFGH (1) • Shortest distance 20 (1) <p>Exemplar response:</p> <table border="1"> <thead> <tr> <th>Node</th> <th>Distance to node</th> <th>Path to Node</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>0</td> <td>-</td> </tr> <tr> <td>B</td> <td>5</td> <td>A</td> </tr> <tr> <td>C</td> <td>7</td> <td>A</td> </tr> <tr> <td>D</td> <td>12</td> <td>B</td> </tr> <tr> <td></td> <td>11</td> <td>C</td> </tr> <tr> <td>E</td> <td>12</td> <td>B</td> </tr> <tr> <td>F</td> <td>14</td> <td>D</td> </tr> <tr> <td>G</td> <td>18</td> <td>E</td> </tr> <tr> <td></td> <td>16</td> <td>F</td> </tr> <tr> <td>H</td> <td>20</td> <td>G</td> </tr> <tr> <td>Distance</td> <td>20</td> <td></td> </tr> <tr> <td>Shortest path</td> <td>ACDFGH</td> <td></td> </tr> </tbody> </table>	Node	Distance to node	Path to Node	A	0	-	B	5	A	C	7	A	D	12	B		11	C	E	12	B	F	14	D	G	18	E		16	F	H	20	G	Distance	20		Shortest path	ACDFGH			6
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