Topic 4

Data Types, Data Structures and Algorithms

1(a)

A computer scientist has created the following logic circuit shown in **Fig. 6**.

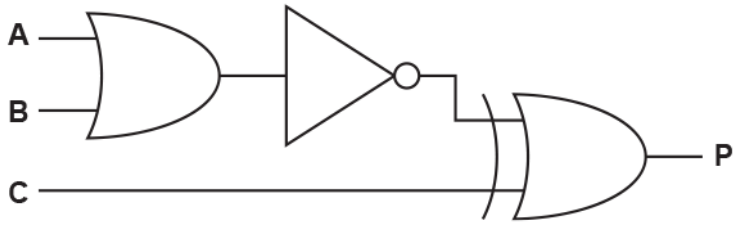


Fig. 6

(i) Give the Boolean expression that represents the logic circuit shown in **Fig. 6**. Do not attempt to simplify the expression.

---

[2]

(ii) Complete the truth table for the logic circuit shown in **Fig. 6.**

A	B	C	P
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

[3]

(b) The following Karnaugh map represents another logic circuit.

CD \ AB	00	01	11	10
00	1	1	1	1
01	1	1	0	0
11	0	0	0	0
10	0	0	1	1

Use this Karnaugh map to find the simplified expression for this circuit.

You should highlight the map as appropriate and write the expression here.

---

[4]

2(a)

(i) Convert the denary number **189** to hexadecimal.

---

[1]

(ii) Convert the unsigned binary number **1010101111** to hexadecimal.

---

[1]

(b) Negative binary values can be represented using either sign and magnitude or two's complement.

(i) Convert the denary number **-107** to an 8-bit binary number using sign and magnitude.

---

[1]

(ii) Convert the denary number **-107** to an 8-bit binary number using two's complement.

---

[1]

(iii) Give **one** advantage of storing values using two's complement instead of sign and magnitude.

---

[1]

(c) The normalised floating point binary number 0100 1110 is stored using 4 bits for the mantissa and 4 bits for the exponent, both in two's complement.

Convert this number to denary.

You must show your working.

[3]

(d) Complete each of the following sentences relating to the storage of floating point binary numbers with an appropriate word.

Increasing the number of bits used for the mantissa increases the ..... of the number that can be stored.

Increasing the number of bits used for the exponent increases the ..... of the number that can be stored.

[2]

3(a) Sundip writes an algorithm to carry out addition and subtraction. The algorithm will use an initially empty stack with the identifier `numbers` and will take input from the user.

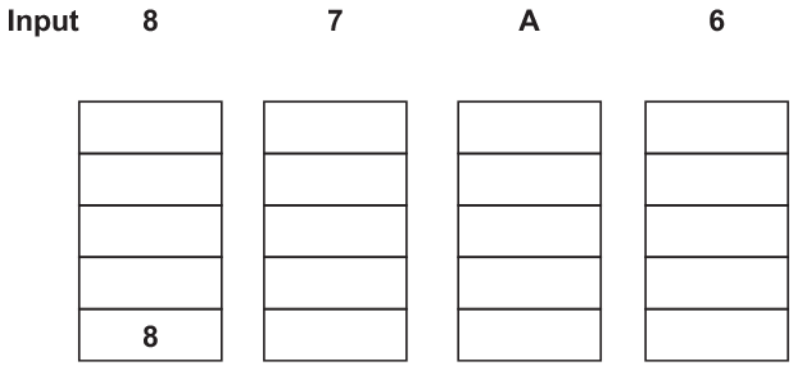
The action the algorithm takes depends on the value input by the user. These actions are listed in **Fig. 2**.

Value input	Action to take
A	• Pop two values from the `numbers` stack • Add the two values • Push the result back onto the `numbers` stack
S	• Pop two values from the `numbers` stack • Subtract the first popped value from the second • Push the result back onto the `numbers` stack
E	• Pop one value from the `numbers` stack • Output this value • End program
Any other value	• Push the input value to the `numbers` stack

Fig. 2

(i) Complete the diagram to show the state of the stack after each value is entered into the algorithm. The letters will complete an action stated in **Fig. 2**.

The state of the stack after the first value, 8, has been completed for you.



[3]

(ii) Complete the following table to give the output from this algorithm when the following set of inputs are entered by the user. The letters will complete an action stated in **Fig. 2**.

Input data (from left to right)	Output
9 3 A E	
10 5 A 8 S E	
25 5 S 2 3 A S E	

[3]

(iii) If the user enters **4 2 S A E** , the algorithm will not work correctly.

Explain what problem this input data will cause and why the problem occurs.

---

[3]

(b) A stack is one data structure that is available for Sundip to use. She could also use a queue, list, linked list, array or tuple.

(i) Describe **one** difference between a stack and a queue.

---

[2]

(ii) Describe **one** difference between an array and a list.

[2]

(iii) State **how a** tuple is different to a list.

[1]

(iv) Describe how the **second** item in a linked list would be accessed using pointer values.

[3]

4 State the benefit of using a normalised form when representing data as a floating point number.

[1]

5(a) A programmer uses a queue data structure to store data.

(i) Tick **one** box that describes how a queue operates.

☐ Last In First Out

☐ First In First Out

[1]

(ii) The figure below shows a queue data structure that contains a list of names. Alex is at the front of the queue.

Alex	Kofi	Ben	Sundip	Tom			

The operations that can be used on the queue are:

- `enqueue()` – This will add data that is passed in as a parameter to the queue.
- `dequeue()` – This will return the first element in the queue.

Show the contents of the queue after these operations have been performed:

```
enqueue("Charlie")
dequeue()
enqueue("Ling")
dequeue()
enqueue("Sara")
```


[2]

(b) A stack is a type of data structure.

A stack is implemented using these variables:

- `items` – This is used to store an array that contains the data.
- `top` – This is an integer value pointing to the last item of data that was inserted.

`pop()` is one operation that can be performed on a stack. This will remove an item from the top of the stack, or –1 if the stack is empty.

(i) Complete the pseudocode function for the `pop()` operation.

```
function pop()
  if top == …… then
     return –1
  else
     item = items[……]
     top = top – ……
     return ……
  endif
endfunction
```

[4]

(ii) A function called `reverse` uses a stack called `theStack` to reverse data that is passed in as a parameter called `name`. For example, the `name` "Jack" would be returned as "kcaJ" by the function.

`theStack` uses these operations which are already defined as global scope in the program:

- `push()` – This will add data that is passed in as a parameter to the stack.
- `pop()` – This will remove and return the item on top of the stack.

Write the function `reverse` so that it:

- accepts the `name` as a parameter

- uses `push()` to add each character in the `name` to `theStack` separately
- uses `pop()` to return each character from theStack and add it to a variable called `reverseName`
- outputs the variable `reverseName` once all characters have been popped from `theStack`.

You should write your function using pseudocode or program code.

[7]

6 Describe what is meant by the term ‘character set’.

[2]

7 **Fig. 5** shows a graph data structure representing a small section of a parcel delivery network. Each node represents an address where deliveries need to be made. The edges show the possible routes and distances between these deliveries.

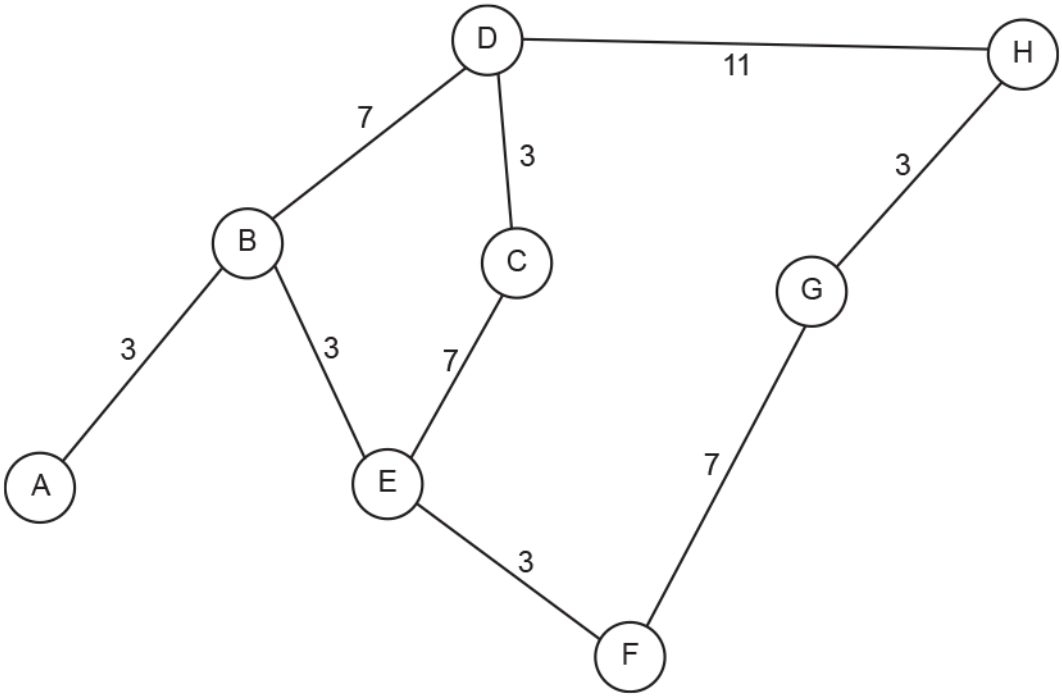


Fig. 5

Give **one** reason why the graph is a visualisation of the problem.

---

[1]

8 Give **one** benefit and **one** drawback of declaring an array as a global variable instead of a local variable.

Benefit ---

Drawback ---

---

[2]

9(a) A veterinary surgery uses a two dimensional array to store bookings for customers to bring in their animal to see the vet. There are ten possible booking slots during each day.

An example of the two dimensional array is shown in **Fig. 1**.

- The first column stores the booking slot number, ranging between 1 and 10.
- The second column stores the time of the appointment.
- The third column stores the customerID of the customer who has booked that slot.

1	9:00	5877RC
2	9:30	9655AS
3	10:00	
4	10:30	8754TT
5	11:00	
6	11:30	8745SD
7	13:00	9635GH
8	13:30	
9	14:00	9874PL
10	14:30	9658SV

Fig. 1

If a customerID has been entered for a booking slot then the booking slot has been taken. If no customerID has been entered then the booking slot is available for booking.

When customers make an appointment they often ask for the first available booking slot.

Describe how a linear search could be used for this purpose.

---

[3]

(b) A function `findFirst`, is used to find the first available appointment.

Write the function `findFirst` that will find the first available appointment and return the booking slot number. If no appointments are available then the function should return "`-1`".

You should write your function using pseudocode or program code.

[7]

10 Trudi would like to sort an array of numbers into order.

The numbers before they have been sorted can be seen here.

89	25	75	37	45

Trudi will use a bubble sort to put these numbers into order from smallest to largest.

Show the first pass of the bubble sort. You should clearly show each comparison made.

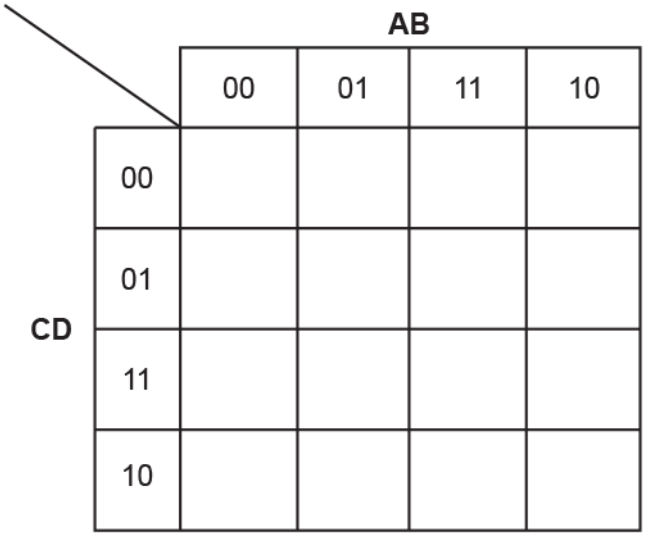
---

[4]

11(a Elliott has designed a logic circuit. The expression he has created for the logic circuit is:
)

$Q = (A \wedge \neg B) \vee (\neg A \wedge C \wedge D) \vee (A \wedge B)$

Complete the Karnaugh Map below to simplify this expression. Show your working.



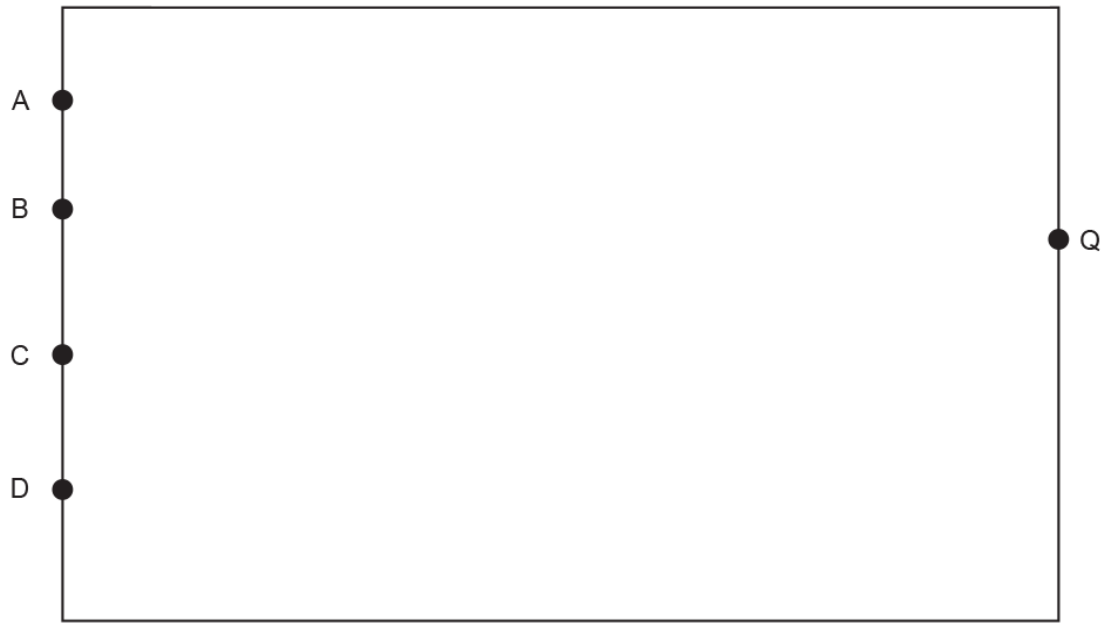
Simplified expression:

---

[4]

(b) Draw a Logic diagram for the following expression:

$$Q = \neg(A \wedge B) \vee (C \wedge \neg D)$$



[3]

12 Draw an XOR gate.

[1]

13 The two below are stored using unsigned binary. Calculate the subtraction of 01110010 from 11000011. Show your working.

```
11000011
01110010 -
--------

--------
```

[2]

14(a) A business uses an array with the identifier `wNames` to store workers' names. A variable with the identifier top is used to store the index of the last element to be added to the array, which is also the element which will next be removed.

wNames

0	1	2	3	4	5	6
Kirstie	Martyn	Louise	Alex	Anna		

top

4

(i) State the name of the type of data structure described above.

---

[1]

(ii) Using pseudocode, write an algorithm that allows the user to enter a name which is then pushed onto the data structure above, checking first that the data structure is not full.

---

[4]

(b) The same workers' names are stored in a binary search tree which is ordered alphabetically.

Kirstie is set as the root node, with Martyn, Louise, Alex and Anna added one by one.

(i) Complete the tree diagram above to show where Martyn, Louise, Alex and Anna would be added to this binary search tree.

[4]

(ii) Describe the process of using the binary search tree above to search for the name "Zoe".

---

[3]

(iii) Compare the efficiency of a binary search tree to a linked list when searching for data.

---

[2]

(iv) Compare the efficiency of a binary search tree to a hash table when searching for data.

---

[2]

15(a) All users of a computer system have a unique username and password. The computer system has implemented two-factor authentication so that users must respond to either an email or text message containing a secret code to be able to access the system.

Let:

A be a Boolean value for if a user enters a valid username

B be a Boolean value for if a user enters a password that matches their username

C be a Boolean value for if a user is able to respond to an email containing a secret code

D be a Boolean value for if a user is able to respond to a text message containing a secret code

Q be a Boolean value for if entry to the computer system is allowed

Complete the Boolean expression below:

Q ≡ ---

(b) Another Boolean expression for a logic system is shown below:

$Q \equiv \neg (\neg A \wedge \neg B)$

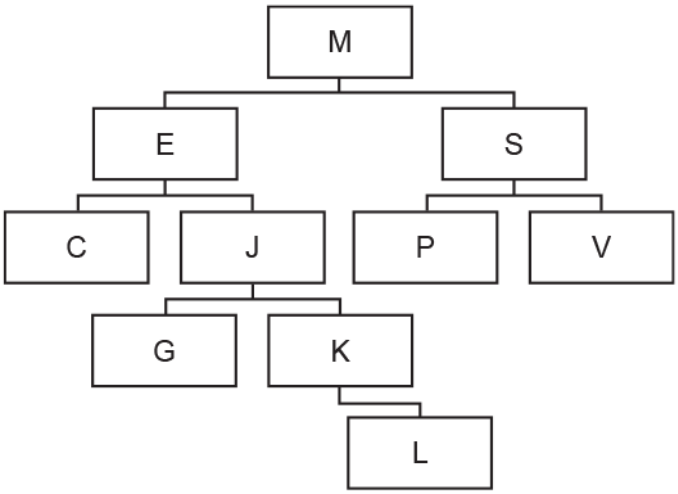
(i) Simplify this Boolean expression so that it does not include any negation. You must explain which Boolean algebra rule(s) you are using at each step.

---

[2]

16 A breadth-first traversal can be performed on both a tree and a graph.

Show how a breadth-first traversal is performed on the following binary tree.



[6]

17(a) Kira is creating a computer game where the user can play against the computer.

In each turn, each character can make one move from a selection of possible moves.

Kira uses a tree data structure shown in **Fig. 1** to identify the range of possible moves the computer can make from starting position A. Each connection is a move, with each node representing the result of the move.

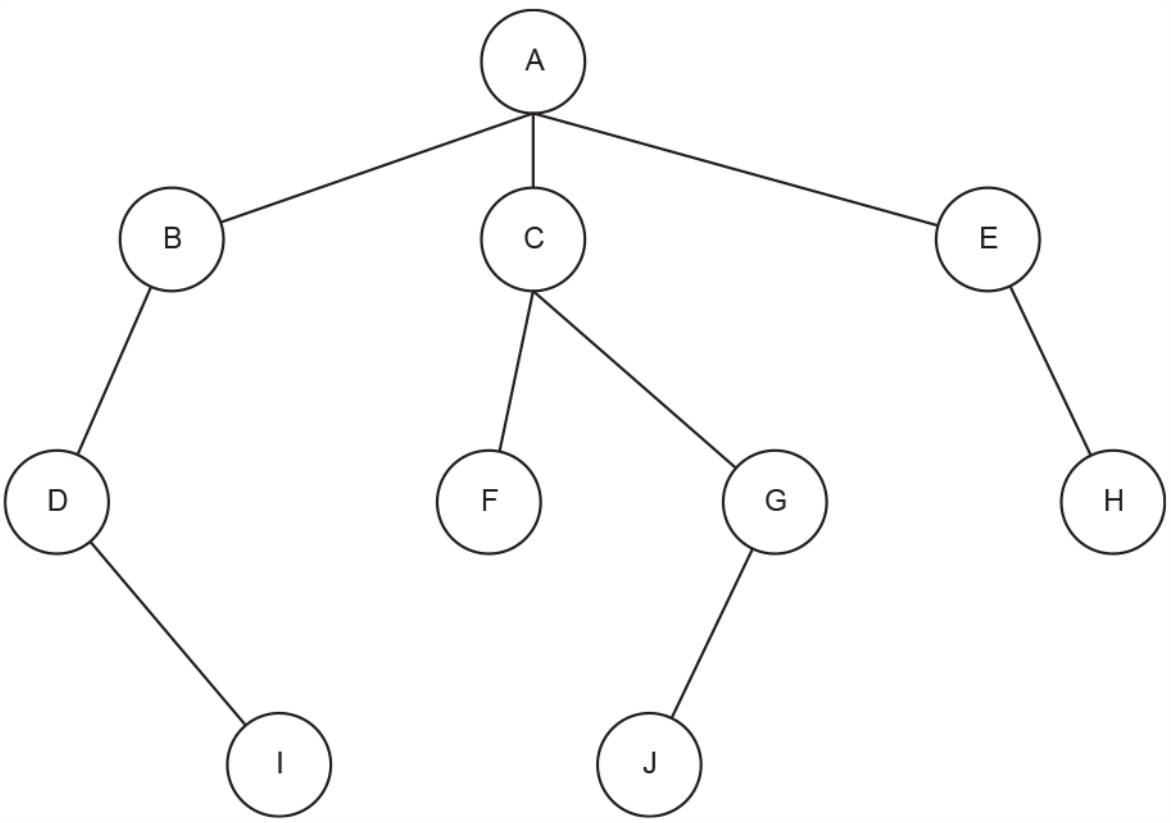


Fig. 1

Kira wants to make some changes to the data that is stored in the tree structure shown in **Fig. 1**.

(i) The move represented by node 'E' needs to be deleted.

Describe the steps an algorithm will follow to delete node 'E' from the tree.

---

[3]

(ii) The move represented by the node ‘K’ needs to be added. Node ‘K’ needs to be joined to node ‘G.’

Describe the steps the algorithm will follow to add node ‘K’ to the right of node ‘G’.

---

[3]

(b) State why the tree shown in **Fig. 1** is **not** an example of a binary search tree.

---

[1]

(c) State what type of pointers are used to store nodes I, F, J and H so they do not point to any other nodes.

---

[1]

18

(i) Show the result of applying an XOR mask of 1100 0111 to the byte 0101 1101.

Byte	0101 1101
XOR mask	1100 0111

[2]

(ii) Describe a mask that could be applied to an 8-bit number to ensure that:

- the most significant bit is always set to 1
- all other bits remain unchanged.

---

[2]

19

(i) State the purpose of a D-type flip-flop circuit.

[2]

(ii) Describe the inputs and outputs used by a D-type flip-flop circuit, explaining how the inputs are used to control the outputs.

[4]

20 Variables in programs contain specific types of data.

Show the denary number 35 as an 8-bit (unsigned) binary number.

[1]

END OF QUESTION PAPER

<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>1</td><td>a</td><td>i</td><td>• ¬ (A ∨ B) // NOT (A OR B)
• ⩒ C // XOR C</td><td>2</td><td>First MP requires brackets, NOT A or B is incorrect.

Can be written in different order (e.g. C XOR NOT (B OR A) as long as logically correct.

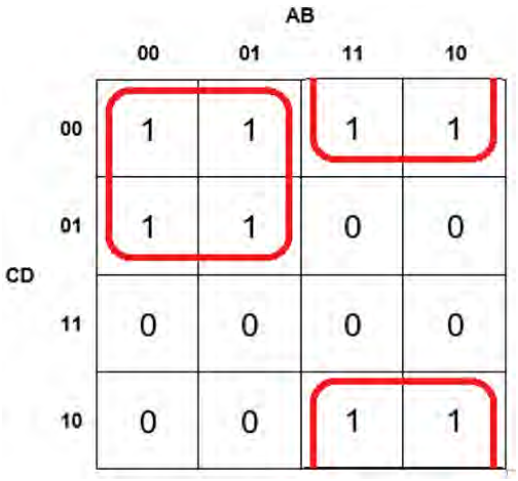
Accept $\overline{(A + B)} \oplus C$

<u>Examiner's Comments</u>

This question was generally well answered, although some candidates confused AND and OR</td></tr>
<tr><td></td><td></td><td>ii</td><td>• 1 mark for first two rows (1,0)
• 1 mark for next two rows (0,1)
• 1 mark for next four rows (0,1,0,1)

<table>
<tr><th>A</th><th>B</th><th>C</th><th>P</th><th>Marking Guidance</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>1</td><td rowspan="2">1 Mark</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>0</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>0</td><td rowspan="2">1 Mark</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>0</td><td rowspan="4">1 Mark</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>1</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>1</td></tr>
</table>
</td><td>3</td><td><u>Examiner's Comments</u>

This question was generally well answered.</td></tr>
</table>

Question			Answer/Indicative content	Marks	Guidance
	b		• Correct highlighting on K map as shown • ¬A ∧ ¬C // $\overline{A}.\overline{C}$ // NOT A AND NOT C… • A ∧ ¬D // $A.\overline{D}$ D // A AND NOT D… • …∨ // + // OR joining the 2 correct expressions together	4	 Do not penalise candidates who attempt to simplify even further (e.g. NOT A AND NOT C = NOT (A OR C) using De Morgan's). MP1 - correct answer only MP4 is dependent on MP2 & 3 <u>Examiner's Comments</u> There were many candidates who were able to gain full marks on this question. Those who did not showed a lack of understanding of grouping on a Karnaugh map, either grouping to include zeros or missing the wrapping group and adding another group in for the top row.
			Total	9	

Question			Answer/Indicative content	Marks	Guidance
2	a	i	• BD	1	Correct answer only Examiner's Comments Binary and hexadecimal questions were generally well answered with many candidates being able to gain full marks across the question parts.
		ii	• 2AF	1	Correct answer only Examiner's Comments Binary and hexadecimal questions were generally well answered with many candidates being able to gain full marks across the question parts.
	b	i	• 1110 1011	1	Correct answer only Examiner's Comments Binary and hexadecimal questions were generally well answered with many candidates being able to gain full marks across the question parts.
		ii	• 1001 0101	1	Correct answer only Examiner's Comments Binary and hexadecimal questions were generally well answered with many candidates being able to gain full marks across the question parts.

Question			Answer/Indicative content	Marks	Guidance
		iii	• Calculations are more easily **performed** on two's complement • Two's complement allows for a (negligible) larger range of numbers to be stored // by example • No additional hardware is required in two's complement // Addition and subtraction are carried out using only an adder • Two's complement has only one representation for 0	1	Accept the reverse of the MP Examiner's Comments Binary and hexadecimal questions were generally well answered with many candidates being able to gain full marks across the question parts.
	c		• Exponent is -2 • Binary point moved **2** places **left** (0.001) // 0.5 x 2^{-2} • 0.125 // 1/8 (one eighth)	3	MP2 is for correct working of whichever method is used. If answer is correct and working is shown, 3 marks Examiner's Comments Binary and hexadecimal questions were generally well answered with many candidates being able to gain full marks across the question parts.
	d		• precision / accuracy • range / size / magnitude	2	Examiner's Comments Many candidates attempted this question with many showing a good understanding of floating-point binary. The most common error was to get the answers the wrong way round giving size or range for the first gap and precision or accuracy for the second.
			Total	**10**	

Question			Answer/Indicative content	Marks	Guidance
3	a	i	• 8, 7 • 15 • 15,6	3	One mark per stack diagram Examiner's Comments This question was generally well answered although some candidates struggled to understand the concept of a stack and how data is pushed on to it and popped from it.
		ii	• 12 • 7 • 15	3	Examiner's Comments This was generally well answered, with the biggest misunderstanding being the way the subtraction occurs.
		iii	• S causes the two values inputted to be popped and only one value to be pushed back // 4 and 2 are popped and 2 is pushed • A causes an attempt to pop **two values but only one present / not two values there** • Causing a **stack** underflow	3	Examiner's Comments Many candidates were able to gain at least one mark on this question for stating that the addition would only be able to pop one number. The candidates who gained full marks were able to state the type of error correctly and explain why there was only one value able to be popped after the subtraction.
	b	i	• Stack is LIFO / FILO • Queue is FIFO / LILO • Stack uses one pointer (for head) • Queue uses two pointers (head and tail) • Stack, data is popped/pushed from the top • Queue, data is dequeued from the from the startand enqueued onto the back // a queue can be circular	2	Mark in pairs Accept descriptions of LIFO / FIFO for MP1 and 2 Examiner's Comments Generally well answered with the most popular answer being that a stack is LIFO and a queue is FIFO.

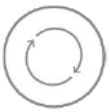
Question			Answer/Indicative content	Marks	Guidance
		ii	• Array is of fixed/defined size // static • List size can be changed // no defined size //dynamic • Array holds data of single data type • List can hold data of multiple / different types	2	Mark in pairs Examiner's Comments Generally well answered, although some candidates confused a list with a linked list.
		iii	• A tuple cannot be changed **at runtime** // a tupleis immutable	1	Examiner's Comments Generally well answered, with a tuple being immutable being the most common answer.
		iv	• **Go to** the first position indicated by the startpointer • From the first position, **read** the next pointervalue… • …follow this pointer value and **access** the data item	3	Accept answers relating to locations given by pointers Allow acceptable diagram illustrating the same points Examiner's Comments For this question candidates were asked how the second item in a linked list would be accessed using the pointers but many just gave descriptions of a linked list having pointers and data without saying how the data in the second item would be accessed.
			Total	**17**	
4			• Allows for more accuracy/precision from the given number of bits • The representation of each binary value is unique	AO1.1 (1)	Examiner's Comments This question was not answered well as many candidates seemed to misread the question. The majority of candidates that answered this question correctly stated that normalised form allowed for greater accuracy/precision from the number of bits.
			Total	**1**	

Question			Answer/Indicative content	Marks	Guidance
5	a	i	☑First In First Out	AO1.1 (1)	Examiner's Comments Most candidates correctly identified that a queue is a 'First in First Out' data structure.
		ii	<table><tr><td>Ben</td><td>Sundip</td><td>Tom</td><td>Charlie</td><td>Ling</td><td>Sara</td><td></td><td></td></tr></table> 1 Mark: Adding, Charlie, Ling and Sara in correct order 1 Mark: Exclusively removing Alex and Kofi.	AO2.1 (2)	Accept: <table><tr><td></td><td></td><td>Ben</td><td>Sundip</td><td>Tom</td><td>Charlie</td><td>Ling</td><td>Sara</td></tr></table> Examiner's Comments This question was generally answered well with most candidates achieving both marks. Some candidates did not correctly dequeue from the front of the queue, or enqueue to the rear.

	b	i	```
			function pop()
			  if top == 0 then
			  return -1
			  else
			  item = items[top]
			  top = top – 1
			  return item
			  endif
			end function
			``
				AO3.2 (4)	Examiner's Comments
					
					Many candidates were given full marks for this question, although some did not correctly return 'item' and incorrectly stated 'items' would be returned.

		ii	• Correctly declaring the function reverse to include passing in name as a parameter
			• Correct logic to calculate the number of pushes required
			• Correct use of a loop to push all characters onto the stack separately
			• Creating a local variable reverseName to hold the reversed string
			• Correct use of a loop to pop all characters from the stack (in the reverse order)
			• Correct logic to add each popped character to the reverseName
				AO3.1 (3)
				AO3.2 (4)
					Example solution
					``
					function reverse(name)
					  reverseName = ""
					
					  for nameCount = 0 to name.Length–1
					
					theStack.push(name[nameCount])
					  next nameCount
					
					  for nameCount = 0 to name.Length–1
					  reverseName = reverseName + theStack.pop()
					  next nameCount
					``

Question			Answer/Indicative content	Marks	Guidance

			variable
			• Correctly returning the reverseName variable
					`return reverseName`
					`end function`
					
					Give full marks for alternative solutions that would work fully.
					
					Allow FT for any duplicate identifiers named incorrectly or using the incorrect case
					
					Examiner's Comments
					
					Although some candidates answered this question well, others were only given 1 or 2 of the available 7 marks. Many candidates that lost marks did not push and/or pop characters correctly, and many did not return a value for the final mark. Candidates should also be reminded that the correct spelling and case of identifiers are required in questions of this type. Some candidates added spaces in identifier names or used a different case to the identifiers stated in the question and therefore, were not given marks.
					
					  Assessment for learning
					
					Candidates need to understand the importance of maintaining the spelling, case and use of spaces etc in identifiers in questions which ask for functions to be written.

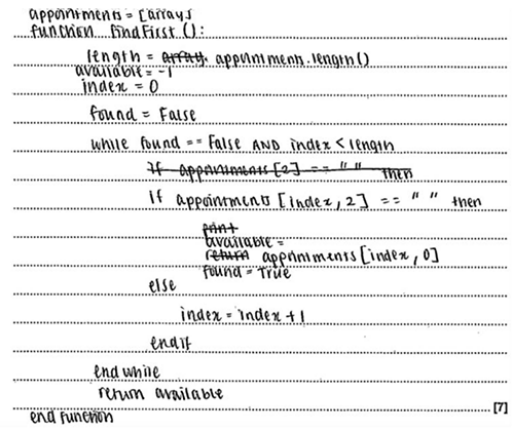
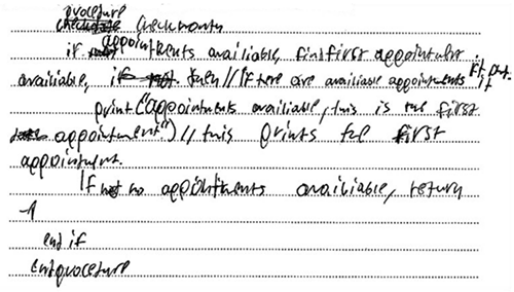
			Total	14	

Question			Answer/Indicative content	Marks	Guidance
6			• List/mapping of characters (that can be understood by the hardware/software/computer) • Each character is given a **unique** binary/numeric code that is stored instead of the character.	AO1.2 (2)	Allow a list of letters /symbols Examiner's Comments Most candidates were given at least 1 mark for this question. Some did not gain the second mark as they missed stating that each character has a unique binary value.
			Total	2	
7			1 mark e.g. • Symbols are used to represent the address • The edges represent possible connections between addresses not the actual physical routes	1	Allow other suitable answers that are in context of the problem Examiner's Comments Very few candidates were able to give suitable answers within the context of the problem. The question was asking why the graph in Fig 5 was a visualisation. Few candidates identified that it was because the letters at the nodes represented delivery addresses, while the weights on the edges represented the road distances between the addresses. Most candidates gave descriptions of visualisation in general rather than answering in context.
			Total	1	

Question			Answer/Indicative content	Marks	Guidance
8			1 mark for benefit, 1 mark for drawback e.g. Benefits: • Variable doesn't need passing as a parameter (byref) • You don't need to return a value • Can be accessed from any function / anywhere in the program Drawback: • Increases memory usage (as it is used until full program execution is over) • Alterations within the function may have unwanted side effects elsewhere in the program.	2	<u>Examiner's Comments</u> Many candidates found it easier to describe a benefit than to give a drawback. The most commonly identified benefit was that the array would have global scope (and would therefore not need to be passed as a parameter), but often the descriptions given were too vague, e.g. 'can be accessed anywhere'. The correct technical vocabulary is required. Drawbacks were poorly described. Potential side effects and resultant complexity debugging were frequently alluded to as 'accidental change' but not fully developed into complete qualified points. There was also a frequent misconception that you cannot have multiple variables with the same name, which is not true. When a local variable is declared with the same name as a global variable that already exists, it takes precedence within the local scope.
			Total	2	

Question			Answer/Indicative content	Marks	Guidance
9	a		1 mark per bullet up to a maximum of 3 marks, e.g.: • To start from the beginning // first booking slot • Search each slot in order // sequentially • Search until the first empty slot is found	3 (AO2.2) (3)	<u>Examiner's Comments</u> This question was generally not well answered. Candidates found it difficult to articulate a clear and concise set of steps that take place during a linear search. Many responses were vague and not directly related to a linear search being performed on the data presented in the table.

	b		1 mark per bullet up to a maximum of 7 marks, e.g.:
			
			• Defining the `findFirst` function correctly
			• Suitable logic for checking the first time slot
			• Suitable logic for checking the next time slot…
			• Suitable loop to check all time slots
			• Suitable logic for returning the available time slot
			• Suitable logic for returning -1 if no time slots available
			• Suitable use of variable names and indentation
				7 (AO3.1) (7)	**Example solution:**
					`function findFirst()`
					`    count = 0`
					`    do`
					`        found = false`
					`        if customerID[2, count] == "" then`
					`            found = true`
					`        else`
					`            count = count + 1`
					`        endif`
					`    until count == 10 or found == true`
					`    if found == True`
					`        return customerID[0,count]`
					`    else`
					`        return -1`
					`    endif`
					`endfunction`
					There are many different ways that this function could have been achieved. Therefore other alternative methods should be given credit.
					
					<u>Examiner's Comments</u>
					A number of candidates started by defining a procedure rather than defining a function. Indentation was not always consistent with the constructs being used. Candidates seemed to have difficulty with referencing two dimensional structures. Algorithms that require two dimensional data frequently appear on this paper and

Question	Answer/Indicative content	Marks	Guidance
			candidates need to have extensive practical programming experience solving problems using these structures. **Exemplar 2**  A well-structured pseudocode response that uses indentation and variable naming well. The logic of the loop to check each item in sequence for an empty entry is clear, as is the indexing into the 2-Dimensional table structure. **Exemplar 3**  To contrast with Exemplar 2, this exemplar shows a lack of pseudocode with a response written mostly in prose English, with inconsistent indentation and a lack of clear variable naming.

<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td>Assessment for learning

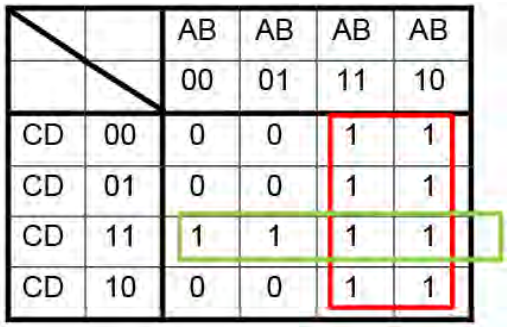
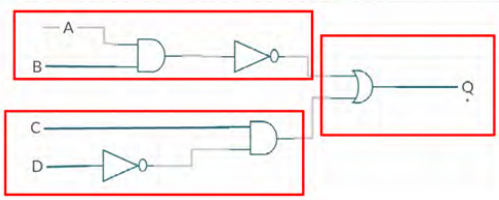
Candidates frequently benefit from having extensive practical programming experience when answering pseudocode questions.

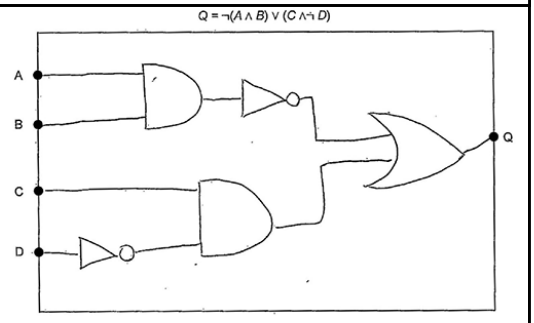
Past paper questions can provide a context for problems for implementation. For this question candidates could either be asked to code a two dimensional table structure for the data in Fig 1 and to then implement the linear search, or they code be provided with a scaffolded partially complete solution with the table defined and the stem of a function given.

Routinely taking past paper questions that can be practically implemented is an effective way to make sure that candidates have relevant experience.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>10</td><td></td></tr>
<tr><td>10</td><td></td><td></td><td>1 mark for each correct row up to a maximum of 4 marks.

<table><tr><td>89</td><td>25</td><td>75</td><td>37</td><td>45</td><td></td></tr><tr><td>25</td><td>89</td><td>75</td><td>37</td><td>45</td><td>1 mark</td></tr><tr><td>25</td><td>75</td><td>89</td><td>37</td><td>45</td><td>1 mark</td></tr><tr><td>25</td><td>75</td><td>37</td><td>89</td><td>45</td><td>1 mark</td></tr><tr><td>25</td><td>75</td><td>37</td><td>45</td><td>89</td><td>1 mark</td></tr></table></td><td>4
(AO2.1)
(4)</td><td>Marks should be awarded for correct swapping of adjacent items that are out of order. Therefore if the previous step is incorrect but the candidate has followed through with the correct answer then marks should be awarded.

<u>Examiner’s Comments</u>
There were a number of responses that included clear diagrams illustrating the first pass of a bubble sort on the given data. Very few candidates confused bubble sort with other types of sorting algorithm so most achieved full marks for this question.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>4</td><td></td></tr>
</table>

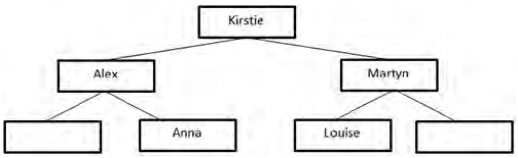
Question			Answer/Indicative content	Marks	Guidance
11	a		Solution:  1 mark per bullet up to a maximum of 4 marks: • 1 mark for filling in the table correctly • 1 mark for the group shown in red • 1 mark for the group shown in green • 1 mark for the simplified expression $A \vee (C \wedge D)$	4 (AO2.1) (2) (AO2.2) (2)	Brackets are not required for the simplified expression Examiner's Comments This question was answered well with many candidates achieving all 4 marks. Some completed the table correctly but were not able to simplify the expression appropriately.
	b		 1 mark per bullet up to a maximum of 3 marks: • An AND gate taking A and B as inputs with the output connecting to a NOT gate • An AND gate taking C and the NOT of D as the inputs • An OR gate taking the outputs of the NOT and AND gates	3 (AO3.1) (3)	Allow NAND gate as alternative for BP1 Examiner's Comments As with the first part of this question, this was answered well. Most candidates used the same gates that are shown in the mark scheme, although equivalent gates were accepted. Some candidates lost marks for not being clear on the type of gate they had decided on. Exemplar 2

Question			Answer/Indicative content	Marks	Guidance
					 Exemplar 2 was given full marks. This candidate has gained all 3 marks as the gates are correct and are clearly drawn to avoid confusion. Each gate also has the correct number of inputs and outputs in all three instances. **Logic gate guidance** To make sure full credit is given for the answers provided, it is essential that the drawings are clear enough to distinguish one gate from another. Some gates look similar, so the lines and symbols need to be clear enough to establish which gate has been used.
			Total	**7**	
12				1 AO1.1	Accept diagram of gate only without input / output <u>Examiner's Comments</u> There were very few candidates who could not correctly draw an XOR gate.
			Total	**1**	

Question			Answer/Indicative content	Marks	Guidance
13			212 002 11000011 01110010 – 01010001 1 Mark for answer 1 Mark for showing working using appropriate binary method.	2 AO2.1	NB some candidates represent carries with **10** as binary 2 rather than **2** Accept answer with missing leading zero. Examiner's Comments Well answered although candidates were required to show their binary working.
			Total	2	

Question			Answer/Indicative content	Marks	Guidance
14	a	i	Stack	1 AO1.1	Correct answer only

		ii	• Input name from user
			• Check if stack is full e.g.(top <=5)
			• If not, update top pointer
			• Correctly push name to index referenced by top
				4 AO3.2	Example answer
					`new = input("enter a name : ")`
					`if top <=5 then`
					`  top = top + 1`
					`  wNames[top] = new`
					`end if`

	b	i	1 mark per name inserted in correct place in diagram	4 AO2.1	
		ii	• Compare with Kirstie – Zoe is larger so go right • Compare with Martyn - Zoe is larger so go right • No right element so stop/not found	3 AO2.2	Allow FT from b(i)
		iii	• Binary tree more efficient than linked list • Do not need to check every value / tree removes half values each time	2 AO1.2	Allow reference to big O for second mark. Linked List O(n), Binary Tree O(log n)
		iv	• Binary tree less efficient than hash table • Hash table can find data immediately / without checking other values.	2 AO1.2	Allow reference to big O for second mark. Binary tree O(log n) Hash table O(1)
			Total	**16**	

Question			Answer/Indicative content	Marks	Guidance
15	a		$Q \equiv A \wedge B$ $\wedge$ $(C \vee D)$	3 AO1.2	$Q \equiv A \wedge B \wedge (C \vee D)$ Accept alternative symbols for AND / OR e.g. Q = A AND B AND (C OR D) Brackets must be included for 3rd point Allow XOR for bullet point 3 Any additional symbols max 2 marks
	b		• Identification of De Morgan's and/or double negation rule • Correct final answer to give A v B	2 AO2.2	
			Total	**5**	
16			1 mark per bullet to max 6 • Visit root node **M** • Visit **E** and **S** • Visit **C** and **J** (from E) • …then **P** and **V** (from S) • Visit **G** and **K** (from J) • Visit **L** (from **K**)	6 AO1.2 (1) AO2.1 (3) AO2.2 (2)	
			Total	**6**	

Question			Answer/Indicative content	Marks	Guidance
17	a	i	1 mark per bullet to max 3 • Search the tree to find the location of Node E // by example of search • Replace the content of node E with blank/null/equivalent • Make node A point to the node H • Add node E to the empty node list	3 AO1.2 (3)	
		ii	1 mark per bullet to max 3 • Search the tree to find the location of node G // by example of search • Create a new node with value K • Add a pointer from node G to the new node • Make node K point to null/equivalent	3 AO1.2 (3)	
	b		One node (node A) has more than 2 connections Nodes aren't ordered (e.g. F is C's left child)	1 AO2.1 (1)	
	c		1 mark for identification • Null pointers	1 AO2.1 (1)	
			Total	**8**	
18		i	• 1001 1010	2 AO1.2	1 mark per nibble, mark left to right
		ii	• 1000 0000 • OR	2 AO2.2	
			Total	**4**	

Question			Answer/Indicative content	Marks	Guidance
19		i	• Delay / store a value… • …of 1 bit • When a signal is given	2 AO1.1	
		ii	• Data input • Clock input • Q output • When clock input goes high… • …Q changes to D • NOT Q is reverse of Q	4 AO1.1 (2) AO1.2 (2)	
			Total	**6**	
20			00100011	1 (AO1.2)	<u>Examiner's Comments</u> In general, most candidates achieved this mark. Some candidates calculated the correct binary value but then did not show their result as an 8-bit binary number. Candidates should be reminded to read the question thoroughly.
			Total	**1**	