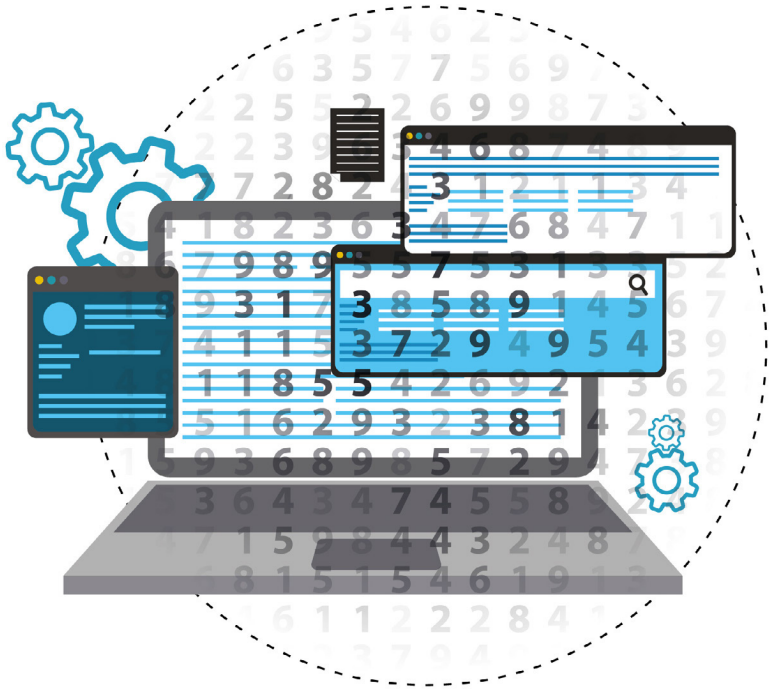
Cambridge Assessment International Education

Specimen Paper Answers – Paper 3

Cambridge International AS & A Level Computer Science 9618

For examination from 2021



Version 2

Cambridge Pathway

Contents

Introduction

The main aim of this booklet is to exemplify standards for those teaching Cambridge International AS & A Level Computer Science 9618, and to show examples of very good answers. We have selected questions from Specimen Paper 3, for examination from 2021.

In this booklet, we have provided responses for Specimen Paper 3 along with examiner comments. Each question is followed by an example of a high grade response with an examiner commentary explaining the strengths and weaknesses of the response. Comments are given to indicate where and why marks were awarded, and how additional marks could have been obtained. In this way, it is possible to understand what candidates have done to gain their marks and how they could improve.

The mark schemes for the Specimen Papers are available to download from Teacher Support/the School Support Hub at www.cambridgeinternational.org/support

2021 Specimen Paper 3 Mark Scheme

Past exam resources and other teacher support materials are also available on the School Support Hub www.cambridgeinternational.org/support.

Assessment overview

Paper 3 – Advanced Theory

Written paper, 1 hour 30 minutes, 75 marks.

Candidates may not use calculators.

Candidates must answer all questions on the paper.

The paper is externally assessed.

Paper 3 is 25% of the A Level and will assess sections 13 to 20 of the syllabus content.

Assessment objectives

The assessment objectives (AOs) are:

AO1: Demonstrate knowledge and understanding of the principles and concepts of computer science, including abstraction, logic, algorithms and data representation.
AO2: Apply knowledge and understanding of the principles and concepts of computer science, including to analyse problems in computational terms.

Question 1

Question 1(a)

1 In a particular computer system, real numbers are stored using floating-point representation with:

- 12 bits for the mantissa
- 4 bits for the exponent
- two's complement form for both mantissa and exponent.

(a) Calculate the normalised floating-point representation of +4.5 in this system. Show your working.

Mantissa **Exponent**

Working .....

.....

.....

.....

..... [3]

Specimen Paper Response

Mantissa **Exponent**

0	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

0	**0**	**1**	**1**

❶

Working

$+4.5 = 100.1_2$ ❷

Normalisation of mantissa $= 0.1001_2 \times 2^3$

Exponent is $3 = 11_2$ ❸

Examiner comment:

❶ The correct value is shown in the space for the mantissa and the exponent on the examination paper. The candidate has also shown the working steps that were required to obtain the answer.

❷ Conversion to binary

❸ Calculation of mantissa to normalise exponent

Total mark awarded 3 out of 3

Question 1(b)

(b) Calculate the normalised floating-point representation of −4.5 in this system. Show your working.

Mantissa												Exponent			

Working .....

.....

.....

.....

..... [3]

Specimen Paper Response

Mantissa												Exponent			
1	0	1	1	1	0	0	0	0	0	0	0	0	0	1	1

❶

Working

*One's compliment of mantissa for +4.5 = 1.01101111111*❷

*Two's compliment of mantissa for +4.5 = 1.01110000000*❸

Exponent remains the same

Examiner comment:

❶The correct value is shown in the space for the mantissa and the exponent on the examination paper. The candidate has also shown the working steps that were required to obtain the answer.

❷Conversion of mantissa for +4.5 to one's complement

❸Followed by conversion of mantissa for +4.5 to two's complement

Total mark awarded 3 out of 3

Question 1(c)

(c) Calculate the denary value for the following binary floating-point number. Show your working.

Mantissa												Exponent			
0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	1

Working .....

.....

.....

.....

.....

Answer .....

[3]

Specimen Paper Response

Mantissa is 0.0011_2 exponent is 5 ❶

Denary number = (1/8 + 1/16) × 32 ❷

= 6 ❸

Examiner comment:

❶ The correct values for the mantissa and the exponent are calculated.
The candidate has also shown the working steps that were required to obtain the answer.

❷ Conversion to denary

❸ Correct answer in denary

Total mark awarded 3 out of 3

Question 1(d)

(d) **(i)** State whether the floating-point number given in **part (c)** is normalised or not normalised.

..... [1]

(ii) Justify your answer given in **part (d)(i)**.

.....

..... [1]

Specimen Paper Response

(i) not normalised. ❶

(ii) The first two bits of the exponent are the same both zeros. ❷

Examiner comment:

❶Correct choice
❷Good justification given showing the reason why this particular number is not normalised.

Total mark awarded (i) 1 out of 1, (ii) 1 out of 1

Question 1(e)

(e) The system changes so that it now allocates eight bits to both the mantissa and the exponent.

Explain **two** effects this has on the numbers that can be represented.

1 .....

.....

.....

2 .....

.....

.....

[4]

Specimen Paper Response

1. *Reduction in precision of the numbers that can be represented ❶ as there are fewer bits available for the mantissa. ❸*
2. *Increase in range of the numbers that can be represented ❷ as there are more bits available for the exponent. ❹*

Examiner comment:

❶ and ❷ each effect of the changes stated has been clearly identified
❸and an explanation given for why the change to the mantissa resulted in this effect
❹and an explanation given for why the change to the exponent resulted in this effect

Total mark awarded 4 out of 4

Question 2

Question 2(a)

2 The TCP/IP protocol suite can be viewed as a stack with **four** layers.

(a) Complete the stack by inserting the names of the **three** missing layers.

Application layer

[3]

Specimen Paper Response

Application layer
Transport layer ❶
Internet layer ❷
Link layer ❸

Examiner comment:

❶ ❷ ❸ each layer has been correctly identified

Total mark awarded 3 out of 3

Question 2(b)

(b) BitTorrent is a protocol used at the Application layer for the exchange of data.

(i) State the network model used with this protocol.

..... [1]

(ii) State the use of BitTorrent.

..... [1]

(iii) Explain how applications use BitTorrent to exchange data.

.....

.....

.....

.....

.....

.....

.....

..... [4]

Specimen Paper Response

(i) *Peer-to-peer*❶

(ii) *File sharing*❷

(iii) *BitTorrent client software is made available,*❸ *this is used to load the torrent descriptor for the required file by computers joining its swarm.*❹ *A server, called a tracker, keeps records of all the computers joining the swarm and allows them to connect to each other by sharing their IP addresses.*❺ *The torrent is split into small pieces that can be down loaded or uploaded by each computer in the swarm.*❻ *Once a computer has downloaded a piece of the torrent file it can upload that piece to other computers in the swarm and become a seed.*

Examiner comment:

Candidate has stated the correct protocol ❶ and what bit torrent is used for ❷ no need to add more as not required by the question. Part (iii) of the question requires an answer that explains how applications exchange data using BitTorrent. The candidate has described, in an appropriate order, four essential actions required; software to use❸, what it is used for❹, how the process is managed❺ and what is uploaded and downloaded❻. The final sentence is not required as the candidate has already gained all of

the marks available, but it does complete the explanation and show that the candidate understands how the process is performed.

Total mark awarded (i) 1 out of 1, (ii) 1 out of 1, (iii) 4 out of 4

Question 2(c)

(c) State **two** other protocols that are used at the Application layer for the exchange of data.

For each protocol, give a different example of an appropriate exchange of data.

Protocol 1 .....

Example .....

.....

Protocol 2 .....

Example .....

.....

[4]

Specimen Paper Response

Protocol 1 *SMTP* ❶

Example *sending email messages* ❷

Protocol 2 *POP3* ❸

Example *retrieval of email messages* ❹

Examiner comment:

Candidate has stated two correct protocols used at the application layer ❶ and ❸. The examples ❷ and ❹ are clear, correct and concise. No further description is required.

Total mark awarded 4 out of 4

Question 3

Question 3(a)

3 (a) Complete the Boolean expession that corresponds to the following truth table.

INPUT			OUTPUT
A	B	C	X
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	1

$X = \overline{A} \cdot B \cdot C$ ..... [2]

Specimen Paper Response

$$X = \overline{A}.B.C + A.B.\overline{C} + A.B.C$$

Examiner comment:

Each Boolean product required for the output X has been included

Total mark awarded 2 out of 2

Question 3(b)

(b) (i) Complete the Karnaugh map (K-map) for the truth table given in **part (a)**.

		AB			
		00	01	11	10
C	0				
	1				

[1]

The K-map can be used to simplify the function in **part (a)**.

(ii) Draw loop(s) around appropriate groups of 1s to produce an optimal sum-of-products. [2]

(iii) Using your answer to **part (b)(ii)**, write the simplified sum-of-products Boolean expression.

X = ... [2]

Specimen Paper Response

(i)

	❶ AB	00	01	11	10
C	0	*0*	*0*	*1*	*0*
	1	*0*	*1*	*1*	*0*

(ii)

	❷ AB	00	01	11	10
C	0	*0*	*0*	*1*	*0*
	1	*0*	*1*	*1*	*0*

(iii) $\mathbf{X} = \mathrm{B.C} + \mathrm{A.B}$ ❸

Examiner comment

Candidate has fully completed the K-map correctly ❶ and shown that there are two overlapping groups ❷. Part (iii) of the question requires a Boolean expression that matches the group identified in the K-map. The candidate has shown two products and each product matches a loop in part (ii) ❸.

Total mark awarded (i) 1 out of 1, (ii) 2 out of 2, (iii) 2 out of 2

Question 4

Question 4(a)

4 A student writes a program in a high-level programming language. A compiler translates the program into machine code.

(a) The compilation process has a number of stages.

The output of the lexical analysis stage forms the input to the next stage.

(i) Identify this stage.

..... [1]

(ii) State **two** tasks that occur at this stage.

1 .....

.....

2 .....

.....

[2]

Specimen Paper Response

(i) *Syntax analysis.* ❶

(ii) 1 *Construction of a parse tree* ❷

2 *Syntax analysis* ❸

Examiner comment:

Candidate has correctly identified the stage in compilation ❶ and stated one task that occurs ❷. The second task stated just repeats the name of the stage ❸. The candidate needs to clearly state what the second task is, for example 'Checking that the rules of the program language grammar have been obeyed'.

Total mark awarded (i) 1 out of 1, (ii) 1 out of 2

Question 4(b)

(b) The program uses pseudocode in place of a high-level language.

There are a number of reasons for performing optimisation. One reason is to produce code that minimises the amount of memory used.

State another reason for the optimisation of code.

..... [1]

Specimen Paper Response

Reduction in the time needed to execute the program. ❶

Examiner comment:

Candidate has accurately stated another reason for code optimisation ❶.

Total mark awarded 1 out of 1

Question 4(c)

(c) The following statement assigns an expression to the variable `A`.

Suggest what a compiler could do to optimise the following expression.

```
A ← B + 2 * 6
```

.....

.....

..... [1]

Specimen Paper Response

*Replace 2 * 6 with the value 12.* ❶

Examiner comment:

Candidate has accurately identified how the code could be optimised ❶.

Total mark awarded 1 out of 1

Question 4(d)

(d) These lines of code are to be compiled:

```
X ← A + B
Y ← A + B + C
```

Following the syntax analysis stage, object code is generated. The equivalent code, in assembly language, is shown below:

```
01  LDD 436 // loads value A
02  ADD 437 // adds value B
03  STO 612 // stores result in X
04  LDD 436 // loads value A
05  ADD 437 // adds value B
06  ADD 438 // adds value C
07  STO 613 // stores result in Y
```

Suggest what a compiler could do to optimise this code.

.....

.....

.....

.....

.....

..... [3]

Specimen Paper Response

Remove the second instance of `LDD 436` *at line* `04` ❶ *and remove the second instance of* `ADD 437` *at line* `05` ❷ *as the value,* `A + B` *is already stored in the accumulator.* ❸

Examiner comment:

Candidate has accurately identified what the compiler needs to do to optimise the object code. Both redundant statements are clearly identified ❶ and ❷. The reason why these actions would optimise the object code is included ❸.

Total mark awarded 3 out of 3

Question 5

Question 5(a)

5 Ed wants to send a message securely. Before sending the message, the software encrypts it using a symmetric key.

(a) (i) Describe what is meant by **symmetric key encryption**.

.....

.....

.....

.....

.....

..... [2]

(ii) State **two** drawbacks of using symmetric key encryption.

.....

.....

.....

.....

.....

..... [2]

Specimen Paper Response

(i) *A single key is used unlike asymmetric encryption where two keys are required.* ❶

(ii) *Everyone who has used the key knows what the key is so* ❷ *they could decrypt any emails that are sent or received using that key.* ❸

Examiner comment:

For part (i) the candidate has identified that a single key is required, there is no further description related to symmetric encryption ❶. For part (ii) the candidate has recognised that any email could be decrypted by the key ❸, the statement that everyone who has used the key could do that ❷ is to vague to gain the second mark.

The candidate could have improved on their performance in part (i) by stating what the key is used in symmetric encryption for, both decryption and encryption of emails. The information given by the candidate about asymmetric encryption is not required by the question. The candidate could

have improved on their performance in part (ii) by providing a more specific answer that mentioned the need for privacy or non-repudiation.

Total mark awarded (i) 1 out of 2, (ii) 1 out of 2

Question 5(b)

(b) The symmetric key is to be exchanged before the message is sent.
To exchange the key securely, the use of quantum cryptography is being considered.

State **two** possible benefits of using quantum cryptography.

.....

.....

.....

.....

.....

..... [2]

Specimen Paper Response

Integrity of the key once transferred can be guaranteed ❶ *as any eavesdropping that has taken place can be identified.* ❷.

Examiner comment:

Candidate has correctly identified that quantum cryptography can guarantee integrity ❶ and that any instance of eavesdropping would be registered ❷.

Total mark awarded 2 out of 2

Question 6

Question 6(a)

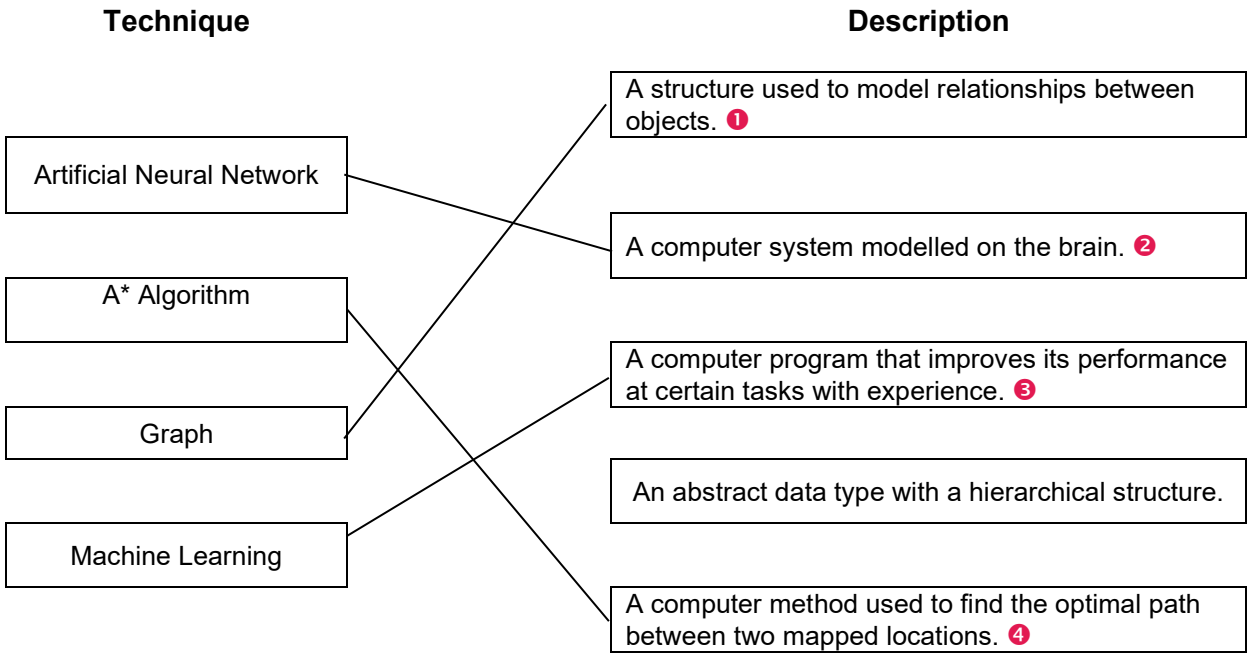
6 (a) Artificial Intelligence (AI) can be aided by the use of different techniques.

Draw a line from each technique to the correct description.

Technique	Description
Artificial Neural Network	A structure used to model relationships between objects.
A* Algorithm	A computer system modelled on a brain.
Graph	A computer program that improves its performance at certain tasks with experience.
Machine Learning	An abstract data type with a hierarchical structure.
	A computer method used to find the optimal path between two mapped locations.

[4]

Specimen Paper Response



Examiner comment:

❶❷❸❹ all descriptions matched to techniques correctly.

Total mark awarded 4 out of 4

Question 6(b)

(b) Describe **two** categories of machine learning.

1 .....

.....

.....

.....

2 .....

.....

.....

.....

[4]

Specimen Paper Response

1 *Supervised learning* ❶ *using known tasks with given outcomes to enable a computer program to improve its performance in accomplishing similar tasks* ❷**.**
2 *Unsupervised learning* ❸ *is the same as supervised without the outcomes* ❹**.**

Examiner comment:

Candidate has correctly identified two categories of machine learning ❶ ❸. The description of supervised learning is clear and accurate ❷, the description of unsupervised is vague and not sufficient as it just highlights a single difference between supervised and unsupervised learning❹.

Total mark awarded 3 out of 4

Question 7

Question 7(a)

7 An ordered binary tree Abstract Data Type (ADT) has these associated operations:

- create tree
- add new item to tree
- traverse tree

A student is designing a program that will implement a binary tree ADT as a linked list of **ten** nodes.

Each node consists of data, a left pointer and a right pointer.

A program is to be written to implement the tree ADT. The variables and procedures to be used are listed below:

Identifier	Data type	Description
`Node`	`RECORD`	Data structure to store node data and associated pointers.
`LeftPointer`	`INTEGER`	Stores index of start of left subtree.
`RightPointer`	`INTEGER`	Stores index of start of right subtree.
`Data`	`STRING`	Data item stored in node.
`Tree`	`ARRAY`	Array to store nodes.
`NewDataItem`	`STRING`	Stores data to be added.
`FreePointer`	`INTEGER`	Stores index of start of free list.
`RootPointer`	`INTEGER`	Stores index of root node.
`NewNodePointer`	`INTEGER`	Stores index of node to be added.
`CreateTree()`		Procedure initialises the root pointer and free pointer and links all nodes together into the free list.
`AddToTree()`		Procedure to add a new data item in the correct position in the binary tree.
`FindInsertionPoint()`		Procedure that finds the node where a new node is to be added. Procedure takes the parameter `NewDataItem` and returns two parameters: • `Index`, whose value is the index of the node where the new node is to be added • `Direction`, whose value is the direction of the pointer (“`Left`” or “`Right`”).

These pseudocode declarations and this procedure can be used to create an empty tree with ten nodes.

```
TYPE Node
    DECLARE LeftPointer : INTEGER
    DECLARE RightPointer: INTEGER
    DECLARE Data : STRING
ENDTYPE
DECLARE Tree  : ARRAY[0 : 9] OF Node
DECLARE FreePointer : INTEGER
DECLARE RootPointer : INTEGER

PROCEDURE CreateTree()
    DECLARE Index : INTEGER
    RootPointer ← -1
    FreePointer ← 0
    FOR Index ← 0 TO 9  // link nodes
        Tree[Index].LeftPointer ← Index + 1
        Tree[Index].RightPointer ← -1
    NEXT
    Tree[9].LeftPointer ← -1
ENDPROCEDURE
```

(a) Complete the pseudocode to add a data item to the tree.

```
PROCEDURE AddToTree(BYVALUE NewDataItem : STRING)
// if no free node report an error

    IF FreePointer .....
        THEN
            OUTPUT "No free space left"
        ELSE
            // add new data item to first node in the free list
            NewNodePointer ← FreePointer

            .....
            // adjust free pointer

            FreePointer ← .....
            // clear left pointer

            Tree[NewNodePointer].LeftPointer ← .....
            // is tree currently empty?

            IF .....
                THEN // make new node the root node

                    .....
                ELSE // find position where new node is to be added
                    Index ← RootPointer
                    CALL FindInsertionPoint(NewDataItem, Index, Direction)
                    IF Direction = "Left"
                        THEN // add new node on left

                            .....
                        ELSE // add new node on right

                            .....
                    ENDIF
            ENDIF
    ENDIF
ENDPROCEDURE
```

[8]

Specimen Paper Response

```
PROCEDURE AddToTree(BYVALUE NewDataItem : STRING)
// if no free node report an error
   IF FreePointer ← -1 ❶
     THEN
       OUTPUT "No free space left"
     ELSE
        // add new data item to first node in the free list
        NewNodePointer ← FreePointer
       Tree[NewNodePointer].Data ← NewDataItem ❷
       // adjust free pointer
       FreePointer ← Tree[FreePointer].LeftPointer ❸
       // clear left pointer
       Tree[NewNodePointer].LeftPointer ← -1 ❹
        // is tree currently empty?
        IF RootPointer ← -1 ❺
          THEN // make new node the root node
              RootPointer ← NewNodePointer ❻
          ELSE // find position where new node is to be added
            Index ← RootPointer
            CALL FindInsertionPoint(NewDataItem, Index, Direction)
            IF Direction = "Left"
              THEN // add new node on left
                  Tree[Index].LeftPointer ← NewNodePointer ❼
                ELSE // add new node on right
                  Tree[Index].RightPointer ← NewNodePointer ❽
            ENDIF
       ENDIF
  ENDIF
ENDPROCEDURE
```

Examiner comment:

Candidate has made a common error by using an assignment (←) instead of testing if the value of the `FreePointer` is equal (=) to `-1` ❶. A new data item has been added in the correct position and an appropriate adjustment made to the `FreePointer` ❷ and ❸. The left pointer has been removed as no longer part of the free list ❹. Candidate has made the same error of using an assignment (←) instead of testing for equality (=)❺. If the list was empty the root pointer has been set to point to the new node. After the call to the procedure `FindInsertionPoint` the `Direction` was checked and the appropriate pointer set to point to the new node ❼ and ❽.

Total mark awarded 6 out of 8

Question 7(b)

(b) The traverse tree operation outputs the data items in alphabetical order. This can be written as a recursive solution.

Complete the pseudocode for the recursive procedure `TraverseTree`.

```
PROCEDURE TraverseTree(BYVALUE Pointer : INTEGER)
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
ENDPROCEDURE
```

[5]

Specimen Paper Response

```
PROCEDURE TraverseTree(BYVALUE Pointer : INTEGER)
    IF Pointer <> -1 ❶
     THEN
       TraverseTree(Tree[Pointer].LeftPointer) ❷
       OUTPUT Tree[Pointer].Data ❸
       TraverseTree(Tree[Pointer].RightPointer) ❹
    ENDIF
ENDPROCEDURE
```

Order correct ❺

Examiner comment:

candidate has tested for the base case ❶ then made a recursive call for left pointer ❷, output the data ❸, then made recursive call for right pointer ❹. The order: visit left, output, visit right is correct ❺.

Total mark awarded 5 out of 5

Question 8

Question 8(a)

8 The following table shows part of the instruction set for a processor. The processor has one general purpose register, the Accumulator (ACC).

Instruction		Explanation
Opcode	**Operand**	
LDM	#n	Load the denary number n to ACC
LDD	<address>	Load the contents of the location at the given address to ACC
STO	<address>	Store the contents of ACC at the given address
ADD	<address>	Add the contents of the given address to the ACC
INC	<register>	Add 1 to the contents of the register
CMP	<address>	Compare the contents of ACC with the contents of <address>
JPN	<address>	Following a compare instruction, jump to <address> if the compare was False
END		Return control to the operating system

(a) State the addressing mode used by:

LDM .....

.....

LDD .....

.....

[2]

Specimen Paper Response

LDM *immediate addressing* ❶

LDD *direct addressing* ❷

Examiner comment:

❶ and ❷, correct modes of addressing identified.

Total mark awarded 2 out of 2

Question 8(b)

(b) Using opcodes from the table, write instructions to set the value at address 509 to the contents of address 500 added to the value 12.

.....

.....

.....

..... [3]

Specimen Paper Response

LDM #12 ❶

ADD 500 ❷

STO 509 ❸

Examiner comment:

❶ ❷ and ❸, each instruction is correct and in the correct order.

Total mark awarded 3 out of 3

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