



# **Cambridge International AS & A Level**

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## **COMPUTER SCIENCE**

**9618/03**

Paper 3 Advanced Theory

**For examination from 2021**

SPECIMEN PAPER

**1 hour 30 minutes**

You must answer on the question paper.

No additional materials are needed.

### **INSTRUCTIONS**

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

### **INFORMATION**

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

This document has **16** pages. Blank pages are indicated.

- 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]

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

Mantissa	Exponent

Working .....  
 .....  
 .....  
 .....  
 ..... [3]

- (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	0 1 0 1

Working .....

.....

.....

.....

.....

Answer .....

[3]

- (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]

- (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]

- 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]

- (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.

.....  
.....  
.....  
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.....

[4]

- (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]

- 3 (a) Complete the Boolean expression 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

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

The part to the right of the equals sign is known as the sum-of-products.

- (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.

$$X = \dots [2]$$

- 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]

- (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]

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

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

A  $\leftarrow$  B + 2 \* 6

.....

.....

..... [1]

- (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.

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[3]

- 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**.

.....  
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.....  
.....  
.....  
.....

[2]

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

.....  
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[2]

(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.

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.....  
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.....  
.....

[2]

- 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]

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

1 .....

.....

.....

2 .....

.....

.....

[4]

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 <code>NewDataItem</code> and returns two parameters: <ul style="list-style-type: none"> <li>• <code>Index</code>, whose value is the index of the node where the new node is to be added</li> <li>• <code>Direction</code>, whose value is the direction of the pointer ("Left" or "Right").</li> </ul>

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

                ..... // 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

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

                ENDIF
            ENDIF
        ENDIF
    ENDPROCEDURE

```

[8]

- (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]

- 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]

- (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.

.....

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.....

[3]

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