Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
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6	
7	
8	
9	
10	
11	
TOTAL	

General Certificate of Education
Advanced Level Examination
June 2010

Computing COMP3

Unit 3 Problem Solving, Programming, Operating Systems, Databases and Networking

Monday 14 June 2010 1.30 pm to 4.00 pm

You will need no other materials.
You may use a calculator.

Time allowed
- 2 hours 30 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 100.
- Questions 2(b) and 9(e) should be answered in continuous prose. You will be marked on your ability to:
  - use good English
  - organise information clearly
  - use specialist vocabulary where appropriate.
- The use of brand names will **not** gain credit.

Answer **all** questions.

1 Data can be transmitted using either serial or parallel data transmission.

1 (a) State **one** advantage of serial data transmission over parallel data transmission.

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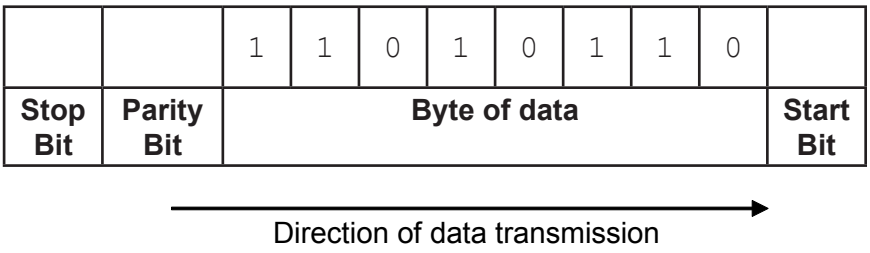
(1 mark)

1 (b) **Figure 1** shows a byte of data being transmitted using asynchronous serial data transmission and even parity.

Write the missing values of the stop bit, parity bit and start bit on **Figure 1**.

Figure 1



(2 marks)

1 (c) Explain what *asynchronous data transmission* is and why start and stop bits are required when it is used.

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(3 marks)

6

2 (a) Explain the purpose of an operating system.

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(2 marks)

2 (b) Discuss the differences between operating systems designed for desktop computers and operating systems designed for embedded systems.

In this question you will also be assessed on your ability to use good English and to organise your answer clearly in complete sentences, using specialist vocabulary where appropriate.

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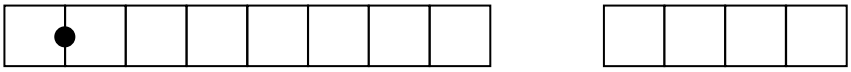
(4 marks)

6

3 A normalised floating point representation uses an 8-bit mantissa and a 4-bit exponent, both stored using **two's complement format**.

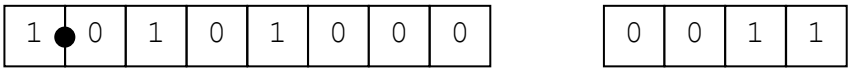
3 (a) In binary, write the largest positive number that can be represented using this normalised floating point system in the boxes below.



Mantissa Exponent

(1 mark)

3 (b) This is a floating point representation of a number.



Mantissa Exponent

Calculate the denary equivalent of the number, showing how you have arrived at your answer.

Working: .....

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Answer: .....

(2 marks)

3 (c) Write the normalised floating point representation of the denary value 13.625 in the boxes below. Space has been provided for you to do rough work.

Rough Work: .....

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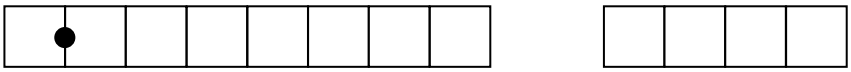
Answer:



Mantissa Exponent

(2 marks)

3 (d) Write the normalised floating point representation of the denary value 0.34375 in the boxes below. Space has been provided for you to do rough work.

Rough Work: .....

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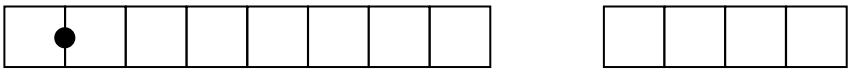
Answer:



Mantissa Exponent

(2 marks)

3 (e) Explain what overflow is and give an example of a situation which might cause overflow to occur.

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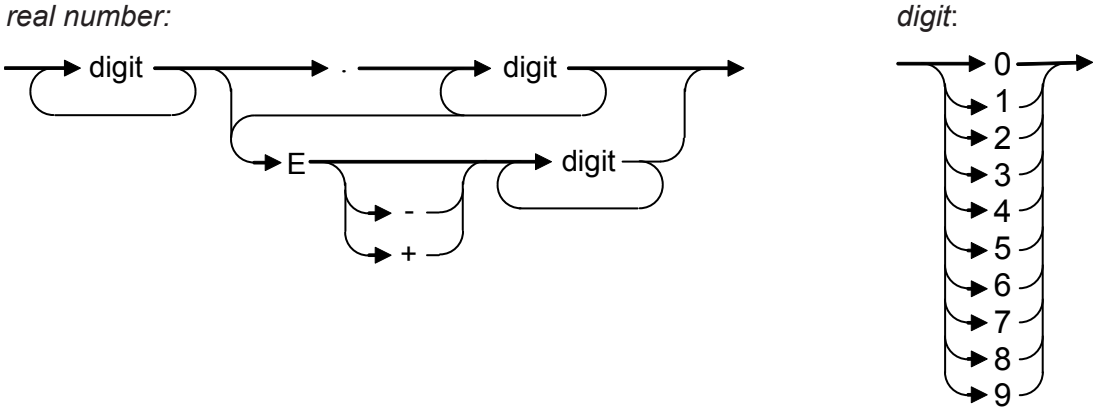
(3 marks)

10

Turn over for the next question

4 In a particular programming language, the correct syntax for a real number is defined by the syntax diagrams in **Figure 2**.

Figure 2



4 (a) Write **Yes** or **No** in the spaces in the empty column of **Table 1** to identify whether or not the numbers listed in the table are valid real numbers which conform to the correct syntax for this language.

Table 1

Real number	Valid? (Yes/No)
203.412	
-12.87	
12.43E-12	

(3 marks)

4 (b) In the same language:

A *digit* is defined as any single numeric symbol from this list: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9.
A *whole number* is defined as a sequence of one or more *digits*.
An *integer* is defined as a *whole number* or a + or a – symbol followed by a *whole number*.

Write Backus-Naur Form (BNF) production rules for *digit*, *whole number* and *integer*.

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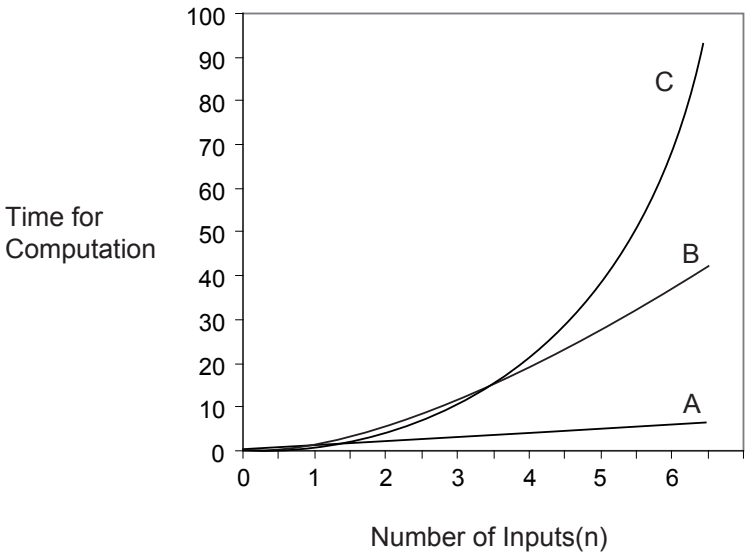
(3 marks)

6

5 **Figure 3** illustrates the time complexity of three different algorithms, A, B and C.

Figure 3



5 (a) The three algorithms have orders of time complexity $O(n^2)$, $O(n)$ and $O(a^n)$.

5 (a) (i) What is the order of time complexity of algorithm C? .....

(1 mark)

5 (a) (ii) Which of the algorithms, A, B or C, is the most time efficient? .....

(1 mark)

5 (b) The Travelling Salesman problem is intractable.

5 (b) (i) What is meant by an *intractable* problem?

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(2 marks)

5 (b) (ii) What approach might a programmer take if asked to 'solve' an intractable problem?

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(2 marks)

6

Turn over ▶

6 A company manages subscriptions to thirty different magazines. Customers can subscribe to receive one or more of the magazines.

- Each magazine has a category such as Gardening or Current Affairs.
- Each magazine has a subscription rate, which is the cost of subscribing to receive the magazine for 12 months.

Details of the subscriptions are to be stored in a database using the following three relations:

Magazine(MagazineID, MagazineName, Category, SubscriptionRate)

Subscription(SubscriptionID, MagazineID, CustomerID, StartDate, EndDate)

Customer(CustomerID, CustomerName, Address, Postcode, TelephoneNumber)

6 (a) These relations are in *Third Normal Form*.

What does this mean and why is it important that the relations in a database are in Third Normal Form?

Meaning: .....

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Why important: .....

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(4 marks)

6 (b) Complete the Entity-Relationship diagram below to show the degree of the **three** relationships that exist between the entities.

Magazine

Subscription

Customer

(2 marks)

6 (c) Complete the following Data Definition Language (DDL) statement to create the Magazine relation, including the key field.

CREATE TABLE Magazine (

.....

.....

.....

.....

.....)

(2 marks)

6 (d) The company wants to send letters to customers with expired subscriptions to the magazine 'AQA Computing Now' to encourage them to subscribe again. The letters must be sent to all customers for this magazine whose subscription ended before 01/06/2010. A customer's name, address and postcode must be included in each letter.

Write an SQL query that will find the data needed to produce the letters.

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(5 marks)

6 (e) The magazine named 'AQA Gardening Monthly' is to be renamed 'AQA Garden News'.

Complete this SQL statement to update the data in the Magazine table to reflect this change.

UPDATE .....

SET .....

WHERE .....

(2 marks)

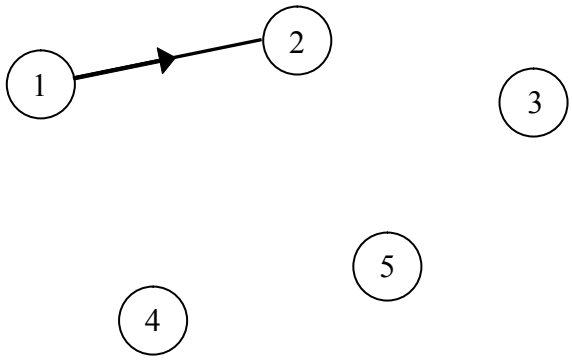
15

7 **Figure 4** shows an adjacency matrix representation of a directed graph (digraph).

Figure 4

From \	1	2	3	4	5
1	0	1	0	1	0
2	0	0	1	1	0
3	0	0	0	0	0
4	0	0	0	0	1
5	0	1	0	0	0

7 (a) Complete this unfinished diagram of the directed graph.



(2 marks)

7 (b) Directed graphs can also be represented by an adjacency list.

Explain under what circumstances an adjacency matrix is the most appropriate method to use to represent a directed graph, and under what circumstances an adjacency list is more appropriate.

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(2 marks)

7 (c) A tree is a particular type of graph.

What properties must a graph have for it to be a tree?

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(2 marks)

7 (d) Data may be stored as a binary tree.

Show how the following data may be stored as a binary tree for subsequent processing in alphabetic order by drawing the tree in the space below. Assume that the first item is the root of the tree and the rest of the data items are inserted into the tree in the order given.

Data items: Jack, Bramble, Snowy, Butter, Squeak, Bear, Pip

(3 marks)

7 (e) A binary tree such as the one created in part (d) could be represented using one array of records or, alternatively, using three one-dimensional arrays.

Describe how the data stored in the array(s) could be structured for **one** of these two possible methods of representation.

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(3 marks)

12

8 A particular Turing machine has states S_1, S_2 and S_3.
S_1 is the start state and S_3 is the stop state.
The machine uses one tape which is infinitely long in one direction to store data.
The machine's alphabet is 0, 1, o, e and □, where □ is the symbol used to indicate a blank cell on the tape.

The transition rules for this Turing machine can be expressed as a transition function δ.
Rules are written in the form:

δ(Current State, Input Symbol) = (Next State, Output Symbol, Movement)

So, for example, the rule:

$$\delta\ (S_1, 0) = (S_1, 0, \rightarrow)$$

means

IF the machine is currently in state S_1 AND the input symbol read from the tape is 0
THEN the machine should remain in state S_1, write a 0 to the tape and move the read/write head one cell to the right

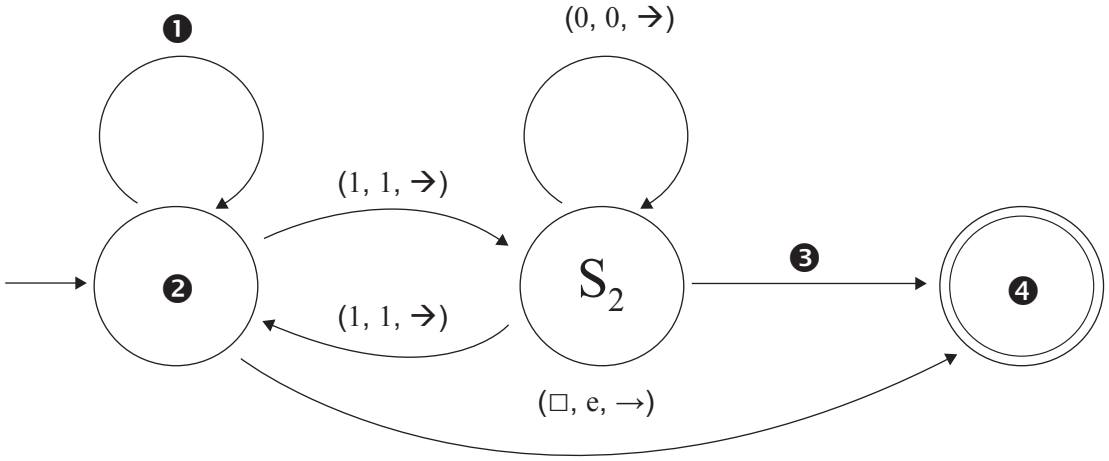
The machine's transition function, δ, is defined by:

$$\begin{aligned}
\delta\ (S_1, 0) &= (S_1, 0, \rightarrow)\\
\delta\ (S_1, 1) &= (S_2, 1, \rightarrow)\\
\delta\ (S_1, \square) &= (S_3, e, \rightarrow)\\
\delta\ (S_2, 0) &= (S_2, 0, \rightarrow)\\
\delta\ (S_2, 1) &= (S_1, 1, \rightarrow)\\
\delta\ (S_2, \square) &= (S_3, o, \rightarrow)
\end{aligned}$$

Figure 5 shows a partially labelled finite state transition diagram for this machine.

Some labels are missing and have been replaced by numbers such as ❶. Each state transition arrow is labelled with the input symbol, the output symbol and the direction of movement, in that order. For example (□, e, →) means that if the input symbol is □, an e is written to the tape and the read/write head moves right one cell.

Figure 5



8 (a) Four labels are missing from **Figure 5**.

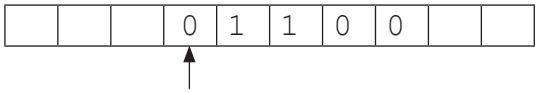
Write the missing labels in **Table 2** below.

Table 2

Number	Correct Label
❶	
❷	
❸	
❹	

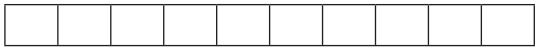
(2 marks)

8 (b) The Turing machine is carrying out a computation using one tape which is infinitely long in one direction. The machine starts in state S_1 with the string 01100 on the tape. All other cells contain the blank symbol, □. The read/write head is positioned at the leftmost zero, as indicated by the arrow.

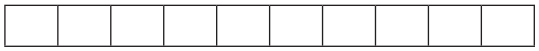


..... Current State: S_1

Trace the computation of the Turing machine, using the transition function δ. Show the contents of the tape, the current position of the read/write head and the current state as the input symbols are processed.



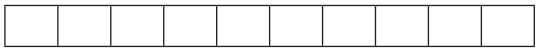
..... Current State:



..... Current State:

..... Current State:

..... Current State:



..... Current State:

..... Current State:

(4 marks)

Question 8 continues on the next page

8 (c) What is the purpose of the algorithm represented by this Turing machine?

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(1 mark)

8 (d) Explain the importance of the theory of Turing machines to the subject of computation.

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(2 marks)

9

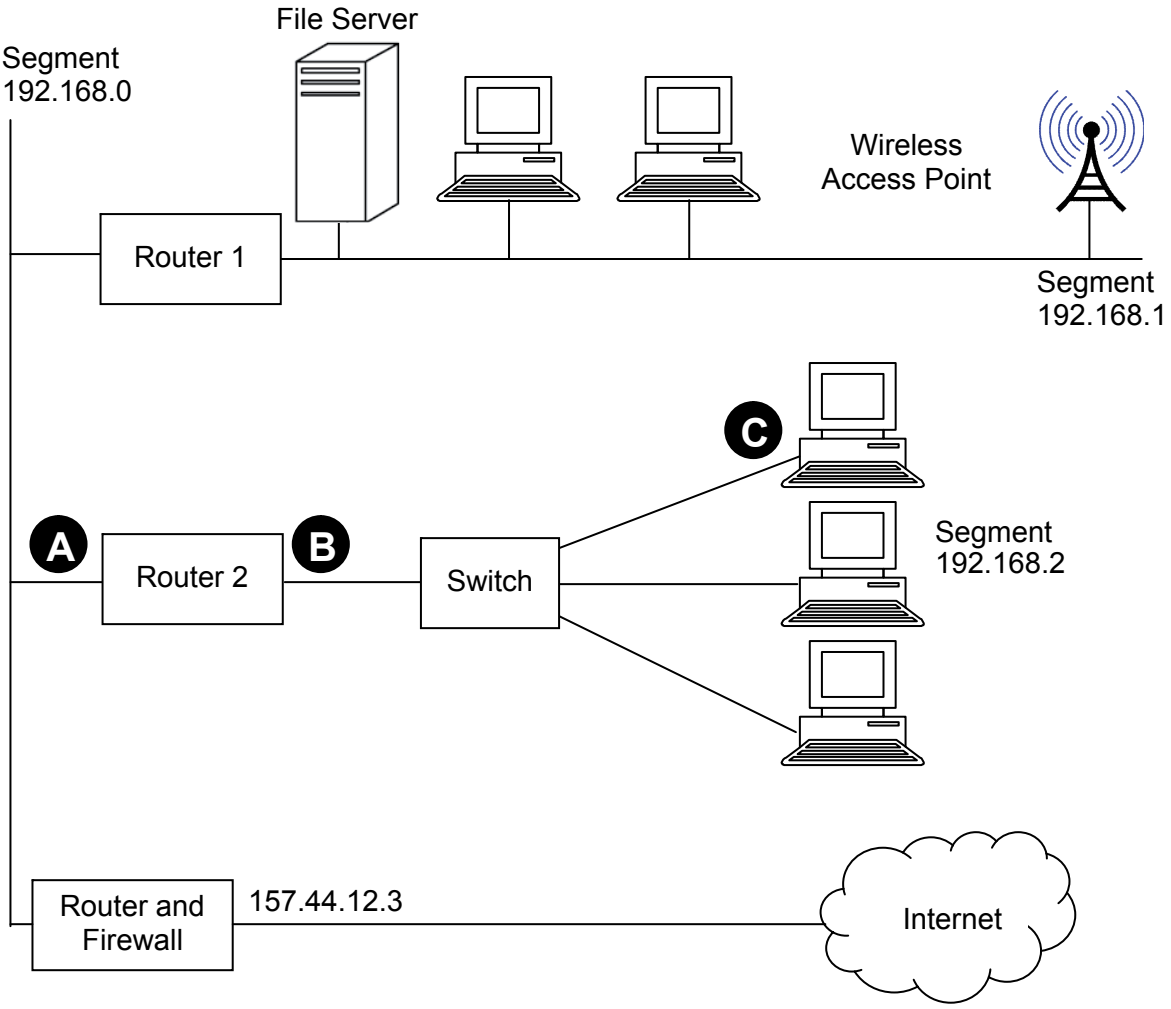
Question 9 begins on page 16

Turn over for the next question

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

9 **Figure 6** shows the topology of a particular computer network that is divided up into segments.

Figure 6



9 (a) Suggest suitable IP addresses for:

9 (a) (i) the "Router 2" port labelled **A**: .....

9 (a) (ii) the "Router 2" port labelled **B**: .....

9 (a) (iii) the computer network interface card labelled **C**: .....

(3 marks)

9 (b) What physical network topology is used within segment 192.168.2 to connect the computers to the switch?

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(1 mark)

9 (c) When the computers in segment 192.168.2 were configured on the network, they were programmed with a subnet mask.

What is the purpose of a subnet mask, and what would the subnet mask be in this case?

Purpose: .....

.....

Subnet mask: .....

.....

(2 marks)

9 (d) Laptop computers connect to the network wirelessly using Wi-Fi. Wireless communication is less secure than communication using cables.

Explain **two** measures that the Wireless Access Point could use to improve the security of the network.

Measure 1: .....

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Measure 2: .....

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(2 marks)

Question 9 continues on the next page

9 (e) The computers in segment 192.168.1 use Carrier Sense Multiple Access with Collision Detection (CSMA/CD) to determine when to transmit data.

Explain how the CSMA/CD method is used, including what happens in the event of a collision occurring.

In this question you will also be assessed on your ability to use good English and to organise your answer clearly in complete sentences, using specialist vocabulary where appropriate.

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(6 marks)

14

Turn over for the next question

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10 A list data structure can be represented using an array.

The pseudocode algorithm in **Figure 7** can be used to carry out one useful operation on a list.

Figure 7

```
p ← 1
If ListLength > 0 Then
  While p <= ListLength And List[p] < New Do
    p ← p + 1
  EndWhile
  For q ← ListLength DownTo p Do
    List[q + 1] := List[q]
  EndFor
EndIf
List[p] ←  New
ListLength ← ListLength + 1
```

10 (a) The initial values of the variables for one particular execution of the algorithm are shown in the trace table below, labelled **Table 3**.

Complete the trace table for the execution of the algorithm.

Table 3

				List				
ListLength	New	p	q	[1]	[2]	[3]	[4]	[5]
4	38	-	-	9	21	49	107	

(4 marks)

10 (b) Describe the purpose of the algorithm in **Figure 7**.

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(1 mark)

10 (c) A list implemented using an array is a static data structure. The list could be implemented using a linked list as a dynamic data structure instead.

10 (c) (i) Describe **one** difference between a static data structure and a dynamic data structure.

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(1 mark)

10 (c) (ii) If the list were to be implemented as a dynamic data structure, explain what the heap would be used for.

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(1 mark)

7

Turn over for the next question

11 An object-oriented program is being written to store details of and play digital media files that are stored on a computer. A class **MediaFile** has been created and two subclasses, **VideoFile** and **MusicFile** are to be developed.

The classes **VideoFile** and **MusicFile** are related to **MediaFile** by single inheritance.

11 (a) Explain what is meant by *inheritance*.

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(1 mark)

11 (b) Draw an inheritance diagram for the three classes.

(2 marks)

11 (c) One important feature of an object-oriented programming language is the facility to override methods (functions and procedures).

Explain what is meant by *overriding* when writing programs that involve inheritance.

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(2 marks)

11 (d) The **MediaFile** class has data fields **Title** and **Duration**.

The class definition for **MediaFile** is:

```
MediaFile = Class
              Public
                Procedure PlayFile
                Function  GetTitle
                Function  GetDuration
              Private
                Title : String
                Duration : Real
            End
```

Note that the class does not have procedures to set the values of the variables as these are read automatically from data stored within the actual media file.

The **MusicFile** class has the following additional data fields:

- **Artist**: Stores the name of the band or singer that recorded the music.
- **SampleRate**: Stores the rate at which the music has been sampled.
- **BitDepth**: Stores the number of bits in which each sampled value is represented.

Write the class definition for **MusicFile**.

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(4 marks)

9

END OF QUESTIONS

There are no questions printed on this page

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